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SOCIAL BEHAVIOR AND SCHOOL STRUCTURE IN PELAGIC PORPOISES (*Stenella attenuata* and *S. longirostris*) DURING PURSE SEINING FOR TUNA

BY

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Final Report on
National Marine Fisheries Service
Contract #01-78-027-1043

Social Behavior and School Structure in
Pelagic Porpoises (Stenella attenuata and S. longirostris)
During Purse Seining for Tuna

by

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This contract was let to study the behavior of purse seine captured dolphins in the eastern tropical Pacific Ocean. The analyses, conclusions and interpretations presented herein are solely those of the authors and are not necessarily endorsed by the National Marine Fisheries Service, Southwest Fisheries Center.

ABSTRACT

Observations were made in the Eastern tropical Pacific of the behavior of spotter and spinner (Stenella attenuata and S. longirostris) porpoises encircled by a purse-seine net during fishing for tuna. Surface observations were made of seventeen encircled schools, and underwater observations of 12, using the focal animal sampling system and a list of 100 behavioral events known to occur in these species. Five-minute case studies were made of 119 individuals. Behavioral events recorded included female and young interactions, courtship, aggressive interchanges, bubble displays, neonate transport, and subgroup composition and relationships. Data suggest much learned behavior and surprisingly low stress levels. Seven kinds of sub-groups were identified in spotters: mother-baby pairs, mother-young subgroups, juvenile subgroups, young adult subgroups, dominant male subgroups, triads and courting pairs. All but the last two were seen in every set of the net, suggesting that aggregations are not random, and are not totally disrupted by fishing procedures. Social interactions were observed between subgroups, and some sets contained up to five separate aggregations of subgroups. Dominant male subgroups, conspicuously marked with white rostrum tips, may be of central importance in the structure and cohesiveness of independent aggregations or "tribes."

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ACKNOWLEDGEMENTS

This study was undertaken as a portion of the Dedicated Vessel Program, a year-long cooperative tuna/porpoise research program under the joint direction of the Marine Mammal Commission (MMC), the National Marine Fisheries Service (NMFS), and the United States Tuna Foundation (USTF). The USTF chartered the commercial tuna seiner, M.V. Queen Mary, to be used as a platform for research throughout 1978. Funds for this study were provided by NMFS.

Phillippe Vergne, Living Marine Resources, was dive-master and also collected behavioral data for this study. Cruise Leader David Bratten, NMFS, and Walter Ikehara, University of Hawaii, provided logistical support at sea. First mate Ralph Silva III, served as diver, shark-guard, and auxiliary photographer. Andrew Britten, U. of H., served as surface shark-guard. Dr. Warren Stuntz, NMFS, was an invaluable source of guidance in the preparation of this report. The data acquisition system, and subsequent computer programming and analysis, were designed with the guidance and supervision of Dr. Ethyl Tobach, American Museum of Natural History, and Dr. Rosamund Gianutsos, Adelphi University. Special thanks must be extended to Captain and Mrs. Ralph Silva, Jr. and to the crew of the Queen Mary, who cooperated in every way with this study and contributed invaluable assistance and information.

INTRODUCTION

Background of this Study

Thousands of oceanic porpoises, or dolphins, are incidentally killed each year during the course of purse seining for yellowfin tuna (Thunnus albacares) in the Eastern tropical Pacific. The porpoise, which swim in association with the tuna, consist principally of three species: the Pacific spotted porpoise (Sten~~n~~hella attenuata), the spinner porpoise (S. longirostris), and the white-belly porpoise (Delphin^us delphis); only the first two species were included in this study.

Porpoise mortality during purse seining is almost always due to entanglement in the net. Animals may become passively entangled, enfolded, or "canopied" by movements of the net, or they may rush at the net or blunder into it actively. While mortality has been reduced from an estimated 300,000 in 1972 to less than 18,000 in 1979, due to improvements in net design and fishing techniques, a goal of the Marine Mammal Protection Act of 1972 is to reduce the incidental kill still further. The Dedicated Vessel Program, of which this study was a part, was directed toward that aim.

Goals of the Study

Specific goals of this study as set forth in NMFS contract #01-78-027-1043 were:

"1. To determine and describe porpoise behavior patterns that indicate such characteristics as fatigue, fear, aggression, courtship, and panic, so the patterns can be recognized by others in the future.

"2. To investigate the composition and behavior of subgroups within captive schools.

"3. To determine the importance of conditioned behavioral patterns in the responses of the porpoise to the fishing operation.

"4. To observe the social behavior of captured porpoises over a longer term by holding the purse seine open at the prebackdown stage for several hours on two or three sets.

"5. To observe the porpoise as they leave the back-down channel and to follow and observe the school for as long as possible after release."

Observations were to be made across the duration of several sets, if possible, to compare sets and to document any changes which might occur during sets.

It was thought that behavioral observations, both below and above water, might provide information on some or all of the following points:

How can mortality be further reduced?

What stress levels are occurring?

How can stressful situations be avoided?

Is stress related to other factors than fishing
per se (e.g., size of school, time of day, age
of individuals)?

What is the nature of the social structure of
the school, and does the fishing procedure
disrupt this structure?

Do males and other animals without young escape
capture more frequently than females with young?

In what ways could learned behavioral adaptations
be facilitated or capitalized on to reduce
mortality?

Does the presence of the net and the vessel
inhibit porpoise orientation underwater?

Finally, while details of social behavior in cetaceans
differ from species to species (Defran and Pryor, 1980) it
was hoped that increased knowledge of the ethology of one or
two species, as obtained in this study, might illuminate our
understanding of cetacean behavior in general. Such under-
standing contributes to basic scientific knowledge and could
benefit the management of cetacean stocks, world-wide.

MATERIALS AND METHODS

Location of Study

The study took place aboard the M/V Queen Mary, from July 10, 1978, to August 18, 19⁷8, in the Eastern tropical Pacific (Figure 1). The Queen Mary, built in 1969, is 151 feet long, has a 34-foot beam, a 17-foot draft, and a 550 ton capacity. The net used during the cruise was 560 fathoms long (3360 feet) and contained a safety panel and superapron. Observations were tied closely into normal fishing procedures, and were made from shipboard, from small boats at the water surface, and underwater. The investigators dove inside the net, using snorkel, mask and flippers, from an outboard-powered rubber raft. An additional diver accompanied each investigator while in the water to guard against sharks.

Recording of Data

Underwater data was recorded on lightly-sanded Lucite slates with ordinary #2B soft drawing pencils. Written and/or tape-recorded field notes were also compiled after each dive, and underwater photographs were taken on five sets with a 35-mm. Nikonos camera.

Additional observations were made after the period of the cruise on six captive spinners at Sea Life Park, Hawaii, to test inter-observer reliability and to record

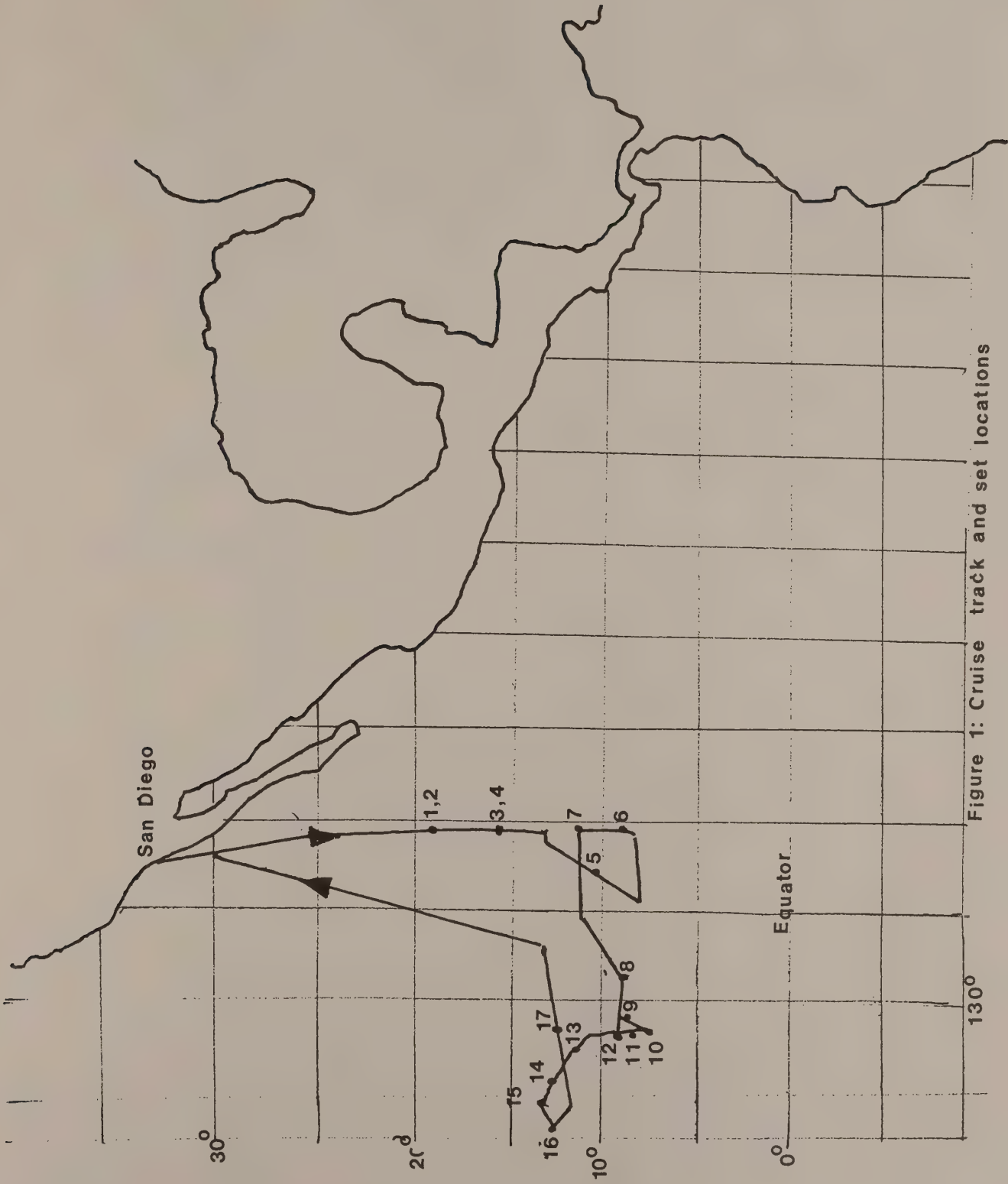


Figure 1: Cruise track and set locations

resting, feeding, and stress-state breathing rates. Also one day's underwater observations were made in Hawaii on a school of spinner porpoises off the leeward coast of Oahu.

During this cruise, 17 sets were made, 9 on pure spotter schools and 8 on mixed spotter and spinner schools. For the purposes of this study sets were divided by event rather than passage of time, into three periods: Setting, the period from letting the net go to the commencement of pursing; pursing and rolling, period from the beginning of pursing until tiedown; and backdown, the period from tiedown to completion of porpoise release and resumption of rolling net. Fishing terminology, fishing procedures, and investigators' procedures are summarized in Table I. Observer positions and other details of data acquisition are presented in Table II.

Data Acquisition Methodology

The primary data acquisition method was based on the focus animal sampling system (Altmann, 1974). This method facilitates observation of minor but perhaps significant events, in addition to major events such as fighting which naturally draw attention when observing a large group of animals. It also permits comparisons between animals and allows quantification of some behavioral data. Individual animals were observed underwater for five-minute periods, and all behavior was recorded in sequence. To reduce bias,

TABLE I

FISHING PROCEDURES

<u>Terminology</u>	<u>Fishing Procedure</u>	<u>Investigators' Actions</u>
Search; hunting; looking for fish	With vessel underway at normal cruising speed (+ or - 12 kt.) crew on high-powered binocular telescopes search for birds, leaping porpoises, or leaping fish.	Pursue normal ship-board duties
The chase	Porpoise are spotted and approached. If captain decides, speedboats are lowered.	
Boats overboard	Speedboats approach the school, and under captain's directions via radio, attempt to herd the school into a single group and drive it back towards the ship.	Watch chase from pilot house and take notes when school becomes visible. Change into diving clothes if necessary.
Circling	When porpoise are on the port beam, the vessel circles them in a dwindling spiral. Porpoise are stopped when they reach the wake of the vessel.	
Making a set	Each time the net is released and retrieved constitutes one "set" of the net.	
Letting go (Command: "Bola!")	The netskiff, a heavy workboat, is released off the stern into the water, drawing the net after it.	Check gear, check and load cameras.
Half-net	When half the net is out, and the porpoise are half-encircled, the half-net warning bell rings. Speedboats patrol the open half of the circle.	Put on hard-hats and assemble with scientific party on net deck (aft deck of ship) to prepare to launch rafts.

Table I, continued

<u>Terminology</u>	<u>Fishing Procedure</u>	<u>Investigators' Actions</u>
"Ortza"	The net is fully in the water when the stern ortza, or bridle attaching the stern end of the net to winch cables, goes overboard.	Divemaster and others lower outboard-powered 4 man rubber raft off starboard side from speedboat davits.
Closing net	When the net skiff reaches the bow of the vessel, the bow ortza is passed manually aft to the net deck. Stern cables pay out until vessel reaches the net skiff. The stern end of the net is then winched in until the two ends meet. The net skiff is deployed to the starboard side and attached to a bridle towing the ship to starboard to counteract forces which tend to pull the ship into the net.	Investigators board raft down the ladder in the ship's hull on the starboard side. The raft traverses the stern cables and travels into the net, approaching the porpoises quietly, slowly, and in a flanking maneuver. Porpoise are milling or travelling slowly on the far side of the net. Additional shark guard in small raft may be picked up on port side and towed behind.
Pursing	The bottom of the net is drawn shut by means of a cable passing through steel rings (the purse rings) along the bottom edge. The rings are brought onto the deck a few at a time as the net is drawn shut.	When near porpoise, divemaster checks for sharks. If none seen investigators enter water and begin observations and data collection. If sharks are present, if visibility is bad, or if sea-state makes the raft unmanageable, investigators return to raft and either tie up to corkline or reboard main vessel.
Rings up	Pursing is completed.	(On some sets, investigators leave water to permit others in scientific party to test fish attractants.)
Rolling net	The stern end of the net is brought on board through a powerblock high above the deck, on the gaff-rigged mast. Weather permitting, the captain rolls net as slowly as possible to prolong underwater observation period.	Continue observations; continue focal animal sampling.

Table I, continued

<u>Terminology</u>	<u>Fishing Procedure</u>	<u>Investigators' Actions</u>
Bow bunches	The bow end of the net, as it folds and puckers due to reduction of bottom circumference, is gathered into bunches to increase flotation and reduce areas of possible porpoise entanglement. Rolling the net on board at the stern also reduces net folding and collapsing.	
Stacking net	All crew members participate in folding the net back and forth as it is lowered on the deck from the powerblock, preparatory to the next set.	
Tiedown	A marker on the net indicates that enough net has now been brought on board so that the porpoise release area is properly positioned for release.	Reboard raft. Porpoise and observers either passively or actively have now become gathered in the release area of net.
Backdown area	The portion of the net over which porpoise will be released is marked by floats, and the normal 4" mesh in this area has been replaced by fine-mesh net, (the Medina panel) to reduce entanglement. The net configuration here is such as to form a sluiceway or channel over which animals can easily pass (the "apron" or "super-apron.")	Investigators tie up to corkline near the backdown area, and continue observations and photography.
Backing down	The vessel is backed up, in a circle, at about 4 kt., drawing the net into a long oval shape. When forces on the net are sufficient, the corkline (top edge of the net, lined with floats) is pulled one or two meters under water, for a width of two to four meters approximately.	

Table I, continued

<u>Terminology</u>	<u>Fishing Procedure</u>	<u>Investigators' Actions</u>
Release; "backing them out"	Porpoise pass across the sunken corkline either actively or passively. A speedboat stationed at the backdown area watches for unreleased porpoise, in which case backing down is continued, or for tuna approaching the opening, in which case the vessel halts momentarily to allow the corklines to pop to the surface and turn the tuna back. A raftman may assist in watching for porpoise or aiding animals across the corkline.	
Post-backdown	The vessel comes to a halt again and resumes rolling net aboard when all porpoise have been released.	Return to vessel and reboard. If sea state prohibits raft's return, speedboat picks up raft and investigators for return.
Sacking up	Net is rolled aboard until the last few fathoms remain (the sack) in which the fish are gathered. Speedboats are brought aboard, if any are still out.	Change clothes and dry off, tape-recording field notes and discussion, while still fresh in mind, at the same time.
Brailling	With the netskiff as a work platform, fish are lifted from the net in a power assisted scoop (the braille) and chuted into frozen brine wells in the ship's hold, for later processing ashore. When all fish have been brought aboard and the last of the net stacked, hunting resumes.	When net winches have stopped, retrieve data slates from raft on net deck, if not already brought aboard. Transfer data from slates to data sheets. Scrub slates. Prepare gear for next dive. Make written notes, corrections and additions to behavioral dictionary, and case tallies.

TABLE II

DATA ACQUISITION

Set #	NMFS Set #	Date	Dive or no dive	# of cases	Whole School	Surface			Photo	Mortality	Setting	Purse + Roll	Backdown
						Observation	Written	Taped					
1	033	7/23	yes	2		x	x				v	w	w
2	034	7/23	no; shark	2	x		x				v	s	s
3	035	7/24	yes	10		x	x				v	w	w
4	036	7/24	yes	8		x	x				v	w	s
5	037	7/28	yes	17	3	x	x				v	w	s
6	038	7/30	aborted: darkness	2	6	x	x	x			v	w + v	s + v
7	039	8/1	aborted: too rough	0		x	x	x	x	2	v	w + s	s
8	040	8/3	yes	5	1	x	x	x			v	w	s
9	041	8/4	yes	6		x	x	x	x		v	w	w
10	042	8/5	yes	35		x	x	x	x		v	w	w
11	043	8/5	no; night set			x	x	x			v	v	v
12	044	8/6	yes	17		x	x	x	x	1	v	w	w
13	045	8/6	aborted: too rough		1	x	x				v	s	v
14	046	8/9	yes	6		x	x	x			v	w	w
15	047	8/9	aborted: too rough		4	x	x				v	s	s
16	048	8/9	no: night set			x	x	x			v	v	v
17	049	8/13	yes	17		x	x	x	x		v	w	w

* v = vessel deck

s = from water surface

w = underwater

sample animals were divided in several ways: (1) into four age groups: baby, juvenile, young adult and old (or large) adult; (2) by sex, in the case of adults; (3) into solitary animals and animals in groups; and (4) into active and inactive animals. A daily tally of these categories was kept to make sure that each group was represented in the final sample insofar as possible. In addition, 12 five-minute sets of observations were taken from the surface, recording the sequence and frequency of the more conspicuous activities of whole schools. Focal animal data were transcribed to paper forms and subsequently to computer cards (Appendix D).

Species Identification

Coloration, spotters having darker backs, and spots, spinners being uniformly grey (sometimes with white bellies) was the primary method of species identification, along with morphological differences and swimming-pattern differences. Also, regardless of age or coloration, all spotters had falcate dorsal fins, and spinners did not. We were not able to separate races or stocks of spinners visually to our satisfaction.

Age Identification

Age identification in spinners was based on comparative size estimates, and in spotters on size estimates and on the degree of spotting, which increases in this species with age

TABLE III

AGE AND SIZE: COMPARATIVE TERMINOLOGY

<u>Age</u> (Pryor & Kang)	<u>Age</u> ¹	<u>Size</u> ²	<u>Coloration (Spotters)</u>	<u>Developmental Categories</u> (Perrin et al, 1976) (Norris, Stuntz and Rogers)
Neonate	1-2 weeks	80-110 cm	grey; fetal folds still visible	neonatal
Baby	2 weeks to 1 year (approx)	100-160 cm or less than 3/4 length of young adult	dark above, light below; no spots	two-tone
Juvenile	1-3 years (approx)	150-180 cm or from 3/4 to full length of young adult	dark above, light below, a few freckles starting up ³	speckled
Young Adult	3 years	160-190 cm	spotted all over	mottled
Large Adults	6 or 7 yrs.	170-200 cm	very dark, very heavily spotted; sometimes a black mask; rostrum tip white (especially males)	fused adult (also including speckled)

¹Age estimates based on captive spinners and spotters.²Figures are adapted from Perrin, et al., 1976.³The term "young" as used herein refers to all babies and juveniles, up to adult size, which are still in association with the mother.

(Perrin, Coe, and Zweifel, 1976). Age and size estimates, and comparative terminology, are presented in Table III.

Sex Identification

Sex identification was made in both species by direct inspection of the genital slits in focal animals, when possible, ^{FEMALES} ~~males~~ usually having a continuous genital slit while that of ^{MALES} ~~females~~ is in two sections. Adult males and females can be easily differentiated in both species by the presence or absence of an enlarged ventral keel on the tail-stock in males.

Terminology

The terms by which females, accompanied by young, are referred to throughout this report require some justification. Specific terms exist for females and young of many species: cat/kitten, mare/foal, goat/kid, and so on, According to scientific custom mother/baby are terms reserved for human beings. The terms cow/calf are sometimes used for whales, but this is not in common usage for porpoises, either by oceanariums, fishermen, or the general public. We have here used the terms mother/baby for porpoises, and mother/young when the offspring is juvenile or adult size, but identifiable as a particular female's young by behavioral cues.* Baby refers specifically to post-neonate but sub-juvenile sized animals, and neonate to animals in their first two weeks,

* See Appendix B.

A GUES'

a useful division which the terms calf or foal or pup do not permit.

We are herein discussing behavioral roles, as much as mere identification, and in the interests of clarity have chosen to use "mother" and "baby" as being generally-understood terms for those roles, rather than the less specific "calf" or awkward circumlocutions (e.g., "adult female accompanied by smaller animal").

Behavioral terminology follows generally-accepted oceanarium usage, which in turn is based on historical whaling terminology (Defran and Pryor, 1980). Where behavioral events were observed which had not been seen in captivity terms were assigned by the investigators (e.g., "free-running," a peculiar, high, splashing leap occurring in individuals right after release, as distinguished from "porpoising," the normal rolling leap of traveling animals, or "running," the long low leap by many animals simultaneously, seen during the chase).

Appendix A presents (1) the behavioral terminology used in this study; (2) computer coding for behavioral events recorded in focal animal cases; (3) descriptive definitions of each behavioral term; (4) the significance or function of the behavior (when known); and (5) where and in which species the behavior was observed.

Table IV presents definitions for some general

TABLE IV
DEFINITIONS

<u>Terms</u>	<u>Meaning</u>
<u>A. VISIBILITY</u>	
Bad visibility	less than 6 meters
Fair visibility	approximately 10-20 m.
Good visibility	30 m. +
Excellent visibility	50-70 m. +
<u>B. DEPTH</u>	
Shallow, near the surface	less than 5 m. below surface
Mid-depth	approximately 7-10 m.
Deep; quite deep	15-20 m.
Very deep	30 m. +
<u>C. INTERANIMAL DISTANCES</u>	
Very close; touching	animals actually touching or within 1-2 pectoral lengths apart
Close	approximately a body-width apart
Bunched	close or very close, swimming rapidly and breathing simultaneously
Together but not close	1-2 m. apart
In the same subgroup	together, and sharing the same swimming speed and orientation
Not in the same subgroup	1 m. or more apart, and not sharing swimming speed and orientation
Separate	3 m. or more from other animals or groups, and not sharing orientation
Crowded	interanimal distances reduced to 1 meter or less in animals not in same subgroups; intergroup distances reduced to 3 m. or less
Jammed	physical contact between many animals; subgroups often not distinguishable

quantitative terms used in the data and in this report.

In order to facilitate future recognition by other observers of absence, presence, and degree of stress (or at least of agitation) in individual animals and in whole schools, we have presented in Table V the behavioral indications of increasing levels of agitation, based on the behavior of spinner and spotter individuals and groups under known circumstances in captivity, together with the usual subjective descriptions ("upset," "calm,") used by trainers. All references to agitation levels in this study can be referred to this table.

Table V also presents a scale for levels of social activity in a school (applicable only to underwater observations).

TABLE V
LEVELS OF AGITATION AND SOCIAL INTERACTION

1. Individual Agitation Levels

<u>Numerical Value</u>	<u>Term</u>	<u>Definition (see Appendix A for Behavioral Terminology)</u>
Level 1	Calm; "normal"	Cruise, surface, breathe, dive in repeated patterns, at moderate speed, or engaged in nonaggressive interaction
Level 2	upset	As above, with addition of gaping, whistling, intermittent rafting and sinking, rapid swimming, and/or engaged in aggressive interaction
Level 3	very upset	Swimming in tight circles or rapidly, or changing direction frequently; loud or frequent whistling; charging, sideswipes, extended aggressive interaction, or shaking body from side to side
Level 4	panicky	As above, but with panic, falling off-balance, struggling, blind rushes, respiratory distress (shipping water in blowhole; foaming exhalation).

Table V (continued)

Agitation Levels, Whole School

<u>Numerical Value</u>	<u>Term</u>	<u>Definition (See Appendix A for Behavioral Terms)</u>
Level 1	calm; very calm	No apparent agitation at surface. Animals moving quietly.
Level 2	nervous, not calm	Porpoising and chuffing .
Level 3	upset; excited	Level 2 activity, plus some headslaps, tailslaps, spyhopping, and/or pink "noses"
Level 4	very upset	Level 3 activity, plus some fluking, tailwaves, sideswipes, aggressive charges, and whistling audible in air.
Level 5	panicky	Level 4 activity, and also panicky dashing about, charging net, struggling

Social Interaction Levels

Level I	Animals not in visible subgroups
Level II	Animals in subgroups, rafting, columning, and/or cruising. Social interactions not conspicuous.
Level III	Level II activities, and also evident mother/baby play and other affiliative or aggressive interactions.
Level IV	Level III activity and also evident and extensive social interactions of long duration or involving several animals (courtship, dominance disputes).

RESULTS

Data Acquisition

In a total of 17 sets, 119 individual focal animal cases were taken below the surface. Fifteen five-minute samples of whole school behavior were taken from the surface (see Table VI).

TABLE VI

DISTRIBUTION OF WHOLE-SCHOOL AND FOCAL ANIMAL CASES

<u>Type</u>	<u>Spotters</u>	<u>Spinners</u>	<u>Mixed Schools</u>
Whole School	11	2	2
Focal animal cases:			
Adult male	26	13	
Adult female	16	2	
Unknown	5	1	
Juvenile	23		
Babies	5		
Mother & babies in pairs	22	6	

During the chase portion of sets preparation for diving precluded methodical observations of whole school

behavior; however the following evasive techniques, presumably adaptive or learned behavior, were observed on one or more occasions:

- Diving under speedboats
- Crossing the bows to starboard, followed by "free-running"
- Diving under the wake
- Diving under net
- "Hiding" (rafting motionless)
- Schools splitting into small groups and going into different directions
- Running for a rain squall
- All animals scattering

On seven occasions groups of animals crossing the bows could be studied closely; all groups contained adults, juveniles and calves (under 1 year size).

Whole-School Behavior

All schools, when set on, took up a similar position in the net, as far from the vessel as possible, at about a "ten-o'clock" position relative to the ship's port side (Norris, et al., 1978; Vergne, 1980). On four sets animals were observed taking up positions in this area enclosed by the ship's wake, well before the net had reached that point. Within the net, animals gathered closely together in this "stationing area." Rafting animals, and animals rising to breathe, often occupied an area at the surface no more than

WHOLE SCHOOL COMPOSITION, SIZE, AND BEHAVIOR IN 17 SETS

1 Time of day at start of chase.

²Agitation levels: 1: No apparent agitation at surface.

2: Porpoising and chuffing.

3: Level 2 + headslaps, tailslaps, spyhopping, pink noses.

4: Level 3 + fluking, tailwaves, sideswipes, charging, whistling audible in air.

5: Level 4 + panicky darting about, charging net, struggling.

³Social interaction levels: see definitions page 16.

20 m. in diameter. Beneath the surface, spotters spread outwards and downwards in an irregular clump, in 9 of 12 sets observed underwater forming a vertical column of moving animals with one or more layers of circling ("cruising") animals below the surface. Spinners, when present, usually circled beneath the spotters, at a greater depth, traveling faster, and forming larger subgroups than the spotters. Spinners rose to breathe in long parabolic arcs, breaking the surface more quickly and briefly than spotters. Although spinners moved more quickly they did not exhibit higher agitation levels (Table V) than spotter schools in the same sets. Spinner schools whistled and made whistle-trails (of bubbles) much more frequently than did spotters. Although spotter and spinner schools stayed close together in each set, no overt social interactions were observed.

Table VII gives summaries of whole-school behavior for each set, including agitation levels (based on surface observations) social interaction levels (when underwater observations were made), and school size estimates.

School Sizes and Divisions

With the exception of set 15, (in which rough seas obscured observation) school counts of less than 300 are based on multiple underwater counts and are probably accurate within 5%. Schools of more than 300 could not be observed

underwater as a unit, so these sizes are not counts but estimates.

Separation of schools into smaller schools (30-200 est.) as seen in chases, was also seen in the nets. In set 3, three groups of spotters remained separate until the net was nearly set. In set 16, with about 1000 animals, two separate groups of rafting spotters were observed. On set 9, about 300 spotters and spinners were encircled: before encirclement, one group of spotters had escaped across the bows and another group escaped under the wake. Within that set, the 300 or so remaining animals were divided into five groups, contiguous but separate: a group of about 30 spotters, mostly rafting, near the investigators; about 70 spinners cruising below the rafting spotters; another mass of 60 + spinners, farther away; a separate group of cruising and columning spotters, beyond the spinners, and yet another mass of spinners dimly visible c. 40 m. away. The animals from this set, on release, were reported as "scattering in all directions."

At no time were spinners or spotters observed by us traveling in very small, isolated groups of 2-5 animals, as has been described for Tursiops truncatus (Bel'kovich, et al. 1978; Wuersig, 1979). While many animals swam in small groups, here called subgroups, those groups were always recognized as being themselves part of larger cohesive groups.

Behavior at Backdown

In every set, by the time of tiedown, all porpoises were gathered in the backdown area. As schools appeared to move circularly on their own axis, but not laterally, it was not possible to tell if their's was a passive or active movement to the backdown area; perhaps both. In set 1, in which a small group of 23 spotters were encircled, the animals waited quietly in the backdown area, remaining in subgroups, and went out quietly with no "free-running," a specific aerial behavior usually exhibited by released animals (Appendix A). In set 2 several spotters became canopied briefly. In set 4, all adults and young faced the corkline, resting quietly but not rafting, while several juveniles swam about calmly below the adults, in the backdown channel, engaging in affiliative interaction. As soon as the corkline sank, animals swam out voluntarily. One slithered over the corkline before it sank and three others bumped the corkline and slid over when their rostra were lifted manually onto the corks. Two animals swam back into the net after swimming out. In set 8, all animals were gathered in the backdown area at tiedown, waiting quietly, when the backdown was temporarily delayed. After approximately ten minutes, the school's agitation level increased from level 1 to level 3. On set 9 animals were jammed almost solidly in the backdown channel, but maintained a 1 m. space between their bodies and the net. Two small

groups of animals "climbed" over the corkline before it sank.

In set 6, no animals went out voluntarily when the corkline sank. Some bumped into the net. Some put their rostra on the corkline but made no effort to slide over. Animals went out of the net sidewise. Many (15 +) swam back into the net after others were clear of the net and free-running.

After release, on all sets, all animals dove, sprinted rapidly underwater, and then departed, usually free-running. On set 9, as mentioned, groups of animals went off in several different directions. On set 10, all the spotters departed to the right and all the spinners to the left. In most sets some or many animals waited in the backdown channel facing towards the vessel, rather than towards the corkline. These animals usually appeared to turn and follow the school only after the corkline had passed beneath them.

Subgroup Composition

A conspicuous feature of both spinners and spotters is the formation of small subgroups within the school, of from two to ten or more animals, swimming together. Seven subgroup types were identified in both species during the study, initially by detailed observation of animals swimming

with focal animals: mother/baby pairs, mother-baby-adult triads, courting pairs, mother/young subgroups, juvenile subgroups, young adult subgroups, and dominant male subgroups. Table VII presents the composition and behavioral characteristics of these subgroups.

Although solitary animals were seen in every set, by far the majority of animals were in subgroups. Of fourteen focal animals selected for being solitary, only 4 remained entirely alone even during the brief five minutes of case study. Age and sex groups in spinners mingled more freely than in spotters. In the larger schools (100 +) an estimated 50% of the spotters present appeared to be in young/adult subgroups.

Other than courting pairs, and triads centered on babies, (both of which were regarded as temporally limited subgroups) the remaining five kinds of subgroups - mother-baby pairs, mother-young, juvenile, young adult, and dominant male subgroups were seen in all sets, even in very small schools, in spotters.

Subgroup Behavior

The basic behavioral characteristics by which subgroups may be recognized have been presented in Table VIII. A more detailed description of behavioral events observed in subgroups is presented below. Specific anecdotal material

TABLE VIII

SUBGROUP COMPOSITION AND IDENTIFICATION

<u>Type of Group</u>	<u>Composition of Subgroup</u>	<u>Behavioral Characteristics</u>
Mother/baby pair	One adult female accompanied by one young; young may be any size from new born to as large as mother. Closeness and constancy of association identify these pairs; size difference is clearly diagnostic.	Two animals, one usually smaller than the other, are in close association. Much contact and body rubbing may occur. Animals do not swim in perfect unison because of twisting around each other. May be slightly apart from and below other animals in school. Few or no aggressive signals.
Mother/baby/adult triad	Two adults with a baby between them. Accompanying adult is usually a female and usually older than the mother, but may also be a male.	Two adults traveling quite fast with a baby sandwiched between them, often touching both adults. Adults evince alarm, swim fast, and avoid rest of school.
Mother/young subgroup	Two or more mother/young pairs with or without additional adult females. The presence of any infant in a group identifies a mother/young subgroup; others in the group are either females or sometimes adult-sized young.	Loosely structured groups which form and dissolve repeatedly, and are characterized by mixed sizes of young present in group, by non-unison swimming due to body-rubbing and pectoral patting both between pairs and among young and other females, and by close interanimal distance.
Courting pair	Two adult animals, one male and one female, swimming together or interacting.	<u>Aggressive Courtship:</u> Two animals circling, stroking, patting, whistling, nuzzling each other, touching heads or rostrums. Tooth-raking may occur. Aggressive signals may be abundant in both animals.

Table VIII, continued

<u>Type of Group</u>	<u>Composition of Subgroup</u>	<u>Behavioral Characteristics</u>
Juvenile subgroup	A group of smaller than full-grown individuals--without spots, in the case of spotters--sticking together closely and exhibiting much unison behavior.	Non-aggressive Courtship: Adult male and female in close association, exchange affiliative contact; male may be oriented toward female rather than swimming in unison with her. Small size and near-perfect synchrony of breathing and swimming mark juvenile subgroups. These groups are also quite autonomous and do not seem to lose or add individuals as, for example, mother-young groups do.
Young adult subgroup	Males and/or females, swimming in constantly changing, merging and reforming groups of from 3 or 4 to more than 20 animals.	These groups make up a large part of the school, do not contain babies, usually do not contain heavily spotted or very large senior adults, and fluctuate constantly in size and composition. Animals may or may not touch each other and may or may not be in unison.
Dominant male subgroup	3-8 very large males swimming in tight formation. Spotter dominant males are heavily spotted and have conspicuous white flashmarks on the tip of the rostrum, which may be seen a long way off.* A cluster of white dots moving by in unison identifies a spotter dominant male subgroup.	Dominant males in a subgroup move close together and in unison, often shoulder-to-shoulder and with striking precision. The school parts to make way for them and they seldom divert from their chosen course. They operate almost entirely in unison, whether giving a threat display or investigating a strange object. They exhibit more curiosity and more aggression than other kinds of groups.

*Very large females may also have white-tipped rostra but marking is not as conspicuous as in large males.

from focal cases and field notes is presented for each subgroup in Appendix B.

Dominant Male Subgroups

Dominant male subgroups, consisting of from three to eight animals, were observed in every set. Some, identified by naturally-marked animals, were seen repeatedly in a given set. While occasionally (cases 007, 008), a male or males would leave or join a male group, usually the numbers in a given subgroup remained constant.

The typical behavior pattern of dominant male subgroups was coordinated cruising (very close or touching) in formation with no animal in advance of another, surfacing, breathing, diving, and cruising again, at a constant but slow speed. Members of dominant spotter male subgroups bore conspicuous white rostrum tips, visible at the extreme range of visibility, before the animal's shapes could be seen, described as "shining," "like stars," and "flashing." Threat displays involving rapid head movements and/or open jaws were accentuated by the white rostrum tips. Both spinner and spotter dominant male subgroups moved through dense masses of other animals without swerving or altering speed, while the other animals, including rafting animals, made way for them. Schools and sections of schools sometimes contained more than one dominant male subgroup. In set 12, among 220 +

spotters, 8 such subgroups were identified.

Activities observed in dominant male subgroups, carried out simultaneously and often in unison, included threat displays to other male subgroups, and investigative excursions (see Appendix B). Activities during which a male would leave and rejoin its subgroup were identified as greeting, guarding, threatening, courting, and aggressive exchanges. See Appendix B, "Subgroup behavioral events," and Appendix C, individual categories, "aggressive" and "greeting."

Mother-baby Pairs

Mother/baby pairs, if not in mother/young subgroups, were often slightly separated from the main body of animals, below and to the side of the school. Some mother/baby pairs exhibited the behavioral pattern common to most non-rafting animals in the school, of cruising, surfacing, breathing, diving, and cruising again. Those which were not cruising often exhibited extensive "play" behavior, including hovering face-to-face, touching rostra and/or melons, gentle mouthing of flukes and pectorals, play-chasing, carrying or beak-genital propulsion by mother to baby, and body-rubbing and stroking. Babies and juveniles of many different sizes were seen in each set.

Babies, or juveniles still with the mother, swam

beside, below, above, but at almost all times slightly behind their mothers, except in set 12 where one adult female was observed following a loudly whistling juvenile (095, 096). Except for the "lost baby" phenomenon (see Appendix B) no animals smaller than 3/4-adult-size juveniles were observed without at least one adult female in close and constant association, and many young which had reached adult length were still in mother-baby pairs (Appendix B).

Mother/Young Subgroups

Mother/young subgroups were seen in every set, and in both spinners and spotters. Any group which contained a baby, or an identifiable mother/young pair, proved to be a mother/young subgroup. The young in these subgroups were of assorted ages. In set 9, a juvenile still paired with its mother (as evinced by mother-young behavioral interaction) was larger than animals in juvenile subgroups in the same set. In set 10 numerous juveniles were reported in mother/young pairs and subgroups which were as large as their mothers.

Mother/young groups did not swim in unison, but in close or very close groups in which leadership and position changed frequently and in which body-rubbing, stroking, and other affiliative behavior (see Appendix A) was evident, and no aggressive behavior was observed. Frequent fluctuations

in group size were observed as pairs joined or left each other. Sometimes an adult female without young would join a mother/young group, or move from one such group to another. Mother/young groups cruised at moderate speed, resembling the speed of most other cruising animals in the school (Appendix B).

Juvenile Subgroups

Juveniles which were not in mother/young pairs, which were 3/4 to small-adult size, and unspotted or speckled, were seen alone (016; 020) or in subgroups of from three to six animals of the same size, i.e., all 3/4 size or all nearly adult size. These subgroups were characterized by small interanimal distances, parallel swimming with no animal in advance of the others, and a strong degree of unison behavior. Fixed numbers of individuals were together throughout the sets. Some juvenile subgroups contained 1 or 2 young adults; in set 10 an adult female swam with a juvenile subgroup of 5, one of which appeared by behavioral cues (pectoral patting, body rubbing) to be her own young.

Triads

Triads consisted of two adults with a small but not neonate (1-7 months, est.) baby sandwiched closely between them. As a rule, triads consisted of a young adult female,

an older female, and a baby. In set 10, female/baby/adult-male triads were seen in both spotters and spinners, and one spinner triad with a male in it was seen repeatedly throughout the set. Most triads moved more rapidly than surrounding animals. Triads were seen to threaten and avoid any animal which attempted to join them (Appendix B).

Young Adult Subgroups

Young adult groups were large, shifting, transitory aggregations of animals which (in spotters) were in the speckled or mottled phase, but not fused. Animals moved into and out of these groups frequently, both in spotters and spinners. Interanimal distances ranged from "close" to "very close" (see Table IV). Some unison swimming was seen, but in general the synchrony in these groups was ragged and intermittent. Some young adult groups appeared to be single-sex, and others mixed. Some young-adult groups engaged in rafting as well as cruising.

Courting Pairs

In this study, adult male-female pairs exhibiting prolonged interaction were considered to be courting pairs. Many courting pairs were seen in sets 5,9,10,12, and 14; no courting pairs were seen in the remainder of the sets. Five pairs of focal animal cases were taken on courting

animals: 033,034; 097,098; 099,100; 108,109; 110,111.

While no copulation or positioning for copulation was observed during these sets, four pairs of copulating spinners in a group of about 15 were seen during a dive among wild schools off Pokai Bay, Oahu, Hawaii, after the Queen Mary voyage.

Courting pairs fell into two categories: those with and those without extensive aggressive behavior. Non-aggressive pairs often swam with or near other animals. Aggressive pairs were usually separated (3 m. +) from other animals, and often consisted of an adult or large adult female (mottled or fused coloration) and a smaller, speckled or mottled male. In these pairs the female hovered stationary in the water for periods of a minute or more, gaping and whistling, while the male engaged in tooth raking. No third animal was ever observed interacting with these pairs; in non-aggressive pairs, however, on at least four occasions another adult male was observed to join the pair, and was threatened with gaping, and, burst-pulse sounds (Appendix A) by the male or by both male and female until the second male left the pair. On one occasion two males, swimming on either side of a female, fenced with open jaws "across her bows," with audible clashings of teeth, before the intruding male left (Appendix B).

Comparative Frequency of Behavioral Events in Subgroups

To make a statistical comparison of behavioral differences in spotter subgroups, all juvenile and adult spotter focal animal cases were assigned to one of six groupings; females with young, juveniles, young adults, courting pairs, dominant males, and solitary animals. Ten of 15 duplicated cases taken on one anomalous juvenile subgroup rafting headdownwards were omitted, as were babies and older young, the behavior of which was either identical to or reciprocal to the mother's behavior, and therefore redundant. Table IX presents the means, standard deviations, and maximum and minimum frequencies for five behavioral events which occurred in most or all subgroups: diving, cruising, surfacing, breathing, and sinking tailfirst. One other behavior which occurred in all subgroups, rafting, is not included in this table because frequency of rafting is not an accurate portrayal of the behavior; animals which rafted intermittantly showed a higher frequency of rafting than animals which rafted continuously throughout the observation period, but were actually rafting less. It should be noted also that a higher frequency of breathing than of surfacing was recorded, because some focal animals remained at the surface during the observation period. Calculations were then made, using the same population sample measured in

Table IX, for all remaining behavioral events which were recorded in focal animals. Appendix E presents calculations of the average number of times each animal in Groups 1-6 performed each behavior, the maximum number of times a given animal performed the behavior, and the percentage of animals in each grouping that performed the behavior at least once (some events which occurred only once, in a single animal, are omitted from this presentation).

Each behavioral event was then categorized (e.g., as affiliative behavior, aggressive behavior, etc., following the categories in Defran and Pryor, 1980) and cumulative averages for each category of behavior were calculated, based on the data in Appendix E. The results of these calculations are presented in Figure 2.

V. Specific Behavioral Events

1. Respiration

Observation of captive animals demonstrates that ordinarily a cetacean respire each time it passes through the air-water interface. A respiration therefore was recorded each time a focal animal surfaced. Respiration of rafting animals, which remained at the surface, was more difficult to observe from below the water, but was indicated by small movements. One rafting animal, selected as a focal animal, held its breath for several minutes, while inspecting the

TABLE IX
COMPARATIVE FREQUENCY OF BEHAVIORAL
EVENTS OCCURRING IN ALL OR MOST SUBGROUPINGS

Group Description

<u>Group Number</u>	<u>Subgroup Type</u>	<u>Number of Cases in Sample</u>
Group 1	females having young	18
Group 2	juveniles	10
Group 3	young adults	11
Group 4	dominant males	16
Group 5	solitary	6
Group 6	courting pairs	11

Behavior

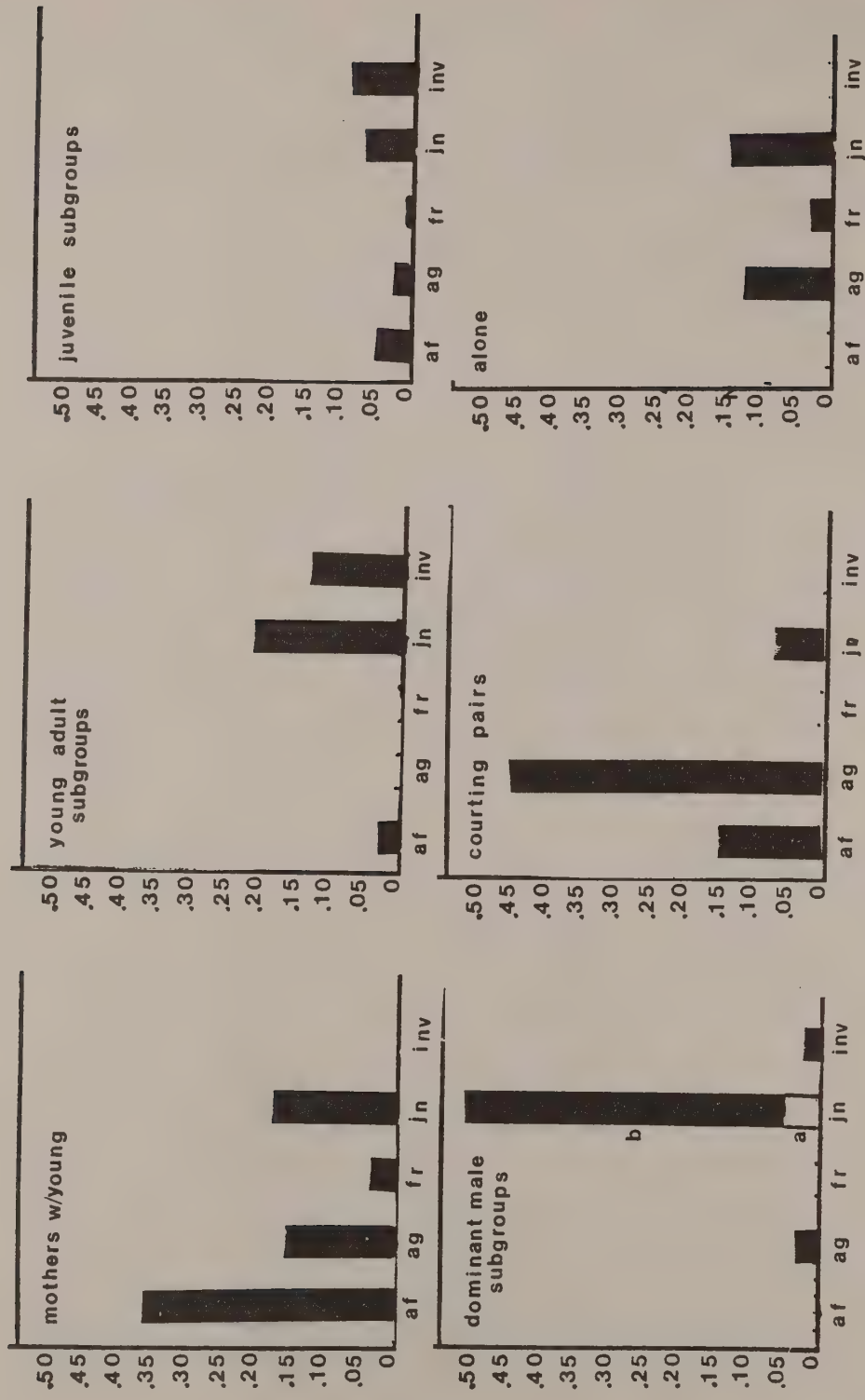
1. Breathing

	<u>Mean</u>	<u>Standard Deviation</u>	<u>Minimum</u>	<u>Maximum</u>
Group 1	4.2	2.2	0	9
2	3.4	0.5	3	4
3	6.0	2.7	1	11
4	4.6	1.3	3	7
5	5.6	3.9	0	10
6	<u>5.9</u>	<u>2.5</u>	2	12
TOTAL	4.7	2.3		

2. Surfacing

Group 1	2.8	2.3	0	7
2	2.3	0.9	1	3
3	2.4	2.4	0	5
4	3.7	1.9	0	6
5	4.3	3.9	0	10
6	3.9	2.1	1	7

	<u>Mean</u>	<u>Standard Deviation</u>	<u>Minimum</u>	<u>Maximum</u>
<u>3. Cruising</u>				
Group 1	1.2	1.4	0	5
2	2.0	2.8	0	6
3	3.1	2.5	0	6
4	2.5	0.8	0	4
5	2.0	1.4	0	4
6	0.7	0.7	0	2
<u>4. Diving</u>				
Group 1	2.5	2.2	0	8
2	3.0	1.4	0	6
3	1.9	1.8	0	4
4	3.8	2.0	0	6
5	3.6	3.8	0	10
6	3.0	3.3	0	8
<u>5. Sinking Tail first</u>				
Group 1	0.5	1.3	0	5
2	0.1	0.3	0	1
3	0.0	0.0	0	0
4	0.1	0.3	0	1
5	0.1	0.4	0	1
6	0.4	0.6	0	2



af=affiliative
ag=aggressive
fr=fear, avoidance
jn=join, leave, merge
inv=investigative

Fig.2. Spotter Porpoise Subgroup Behavioral Differences
Average frequency of occurrence, per animal in a subgroup, of behavior in five categories, taken from 72 Focal Animal case studies. The wide differences in behavioral profiles are also reflected in descriptive data. Mothers and courting pairs show most affiliative behavior. Juveniles and solitary animals avoid other animals. Dominant male groups rarely join others (a) but may be joined by large groups in times of alarm (b). See pp. 36, 37, and Appendix E.

investigator visually with its near eye; the case was begun when the animal resumed respiration (088). Respiration rates of animals during the chase were ordinarily not observable, as individual animals could not be tracked visually, except in one instance when a group of four spotters paced the ship close to the starboard side, and individuals could be observed between surfacings: respiration occurred an average of 10 times per minute.

Spotter respirations were in most focal cases spread at more or less even intervals, while spinners often followed a pattern of surfacing, breathing three or four times in a row, and then diving again for several minutes.

Stress

Stress per se was not considered measureable; however, levels of agitation in individual animals could be rated according to behavioral criteria. These ratings are presented for focal animals in Table X. In some cases (aggressive courting pairs) heightened agitation levels appeared to be due to social interaction. In other cases the cause of agitation was not apparent.

Some behavioral events not known to us from animals in captivity appeared to us to be stress-related, that is, evidences of apprehension, such as disoriented behavior (turning in small circles while whistling loudly), shaking

TABLE X

INDIVIDUAL AGITATION LEVELS

Level 1 Cruise, surface, breathe, dive, cruise, in repeated patterns, at moderate speed, or engaged in nonaggressive interaction such as play.

	<u>Adult Males</u>	<u>Adult Females</u>	<u>Juveniles</u>	<u>Babies</u>	<u>Mother/Young Pair</u>
Spotters:	127 007 029 121	015 102	016		118,119 005 006
	128 008 030 122	038 103	090		130,131 009 010
	129 013 031 123	041 104	091		021 012
	037 032 124	069 105	092		049 022
	048 110 125	094 106	093		067 050
	108 126	109			068
		132			
		111			
Spinners:	023 057	033			026 027
	028 058	034			053 054
	039 059	035			062* 063
	064 060				096
	065 061				

Level 2 As above, but with some gaping, whistling, rapid swimming and/or engaged in aggressive interaction.

Spotters:	017 088	001	052 101	003	011*
	014	002	066 120		113*
	019	018*	070		133 134
	055	098	071		
	056		072		
	087		073		
			074		
			075		
Spinners:	036				
	086				
	089				

Level 3 Swimming in circles or changing direction frequently, shaking body from side to side, rapid swimming, frequent or loud whistling in extended aggressive interaction.

Spotters:	097*		004		095*
			020		112*
Spinners:					

Table X, continued

Level 4: As above but with panic, falling off-balance, and/or struggle, blind rushes, respiratory distress (shipping water in blowhole)

No focal animal cases were seen at this level of agitation.

1. For purposes of this table, adult animals of unrecorded known sex are put with adult females.
2. Asterisked animals are pairs in which the two animals are at different agitation levels.
3. Duplicate cases not included.

the body slowly from side to side, and rafting in clusters, head downwards.

Fear and Avoidance

Schools and individuals in the nets usually avoided or moved away from speedboats, tuna, and incursions of the net. The investigators and their rafts were avoided initially in 5 sets, avoided throughout in one set, and avoided not at all in the remaining sets. In set 2 a slowly moving group of animals surrounded the raft and its passengers, making no effort to move away from the raft even when it touched them. Five animals in this groups flinched, but did not move away, when one investigator waved an arm abruptly.

Underwater, in spotters, mother/baby pairs moved away from the investigators more than did other animals, and sometimes swam farther away when chosen as focal animals. In six sets, individual animals or groups of animals approached the investigators voluntarily, often inspecting them both visually and with sonar, sometimes passing within 1 m. On five occasions adult males threatened swimmers, approaching from behind with an echo-location threat sound (first identified in captive animals) and then hovering broadside and inspecting visually with the near eye. Rafting animals and slowly cruising animals allowed themselves to be touched and stroked, always inspecting the swimmer carefully meanwhile.

Prolonged contact however (+30 sec.) or attempts to restrain the animal elicited avoidance; in such circumstances, animals ceased rafting and swam farther away in the normal cruising swim pattern.

Spinners remained in general farther away from the investigators than did spotters, not apparently due to avoidance but perhaps to their typical pattern of swimming deeper and traveling in wider circles. One male spinner selected as a focal animal while cruising 10-20 m. away approached the investigator after 4 minutes of observation to within 1.5 m. and hovered broadside, making visual inspection.

Aggression

Extended aggressive interchanges in both species were observed only among males, and included gaping, snapping (but not biting), striking sidewise with jaws or flukes, threat sounds and gestures, chasing, (including in spinners chasing of one male by many others), ramming, chasing in circles, and threat displays between two dominant subgroups male (spotters). Adult and young adult females were seen gaping at males and occasionally at their own babies, and gaping, making threat sounds and displays, and tooth-raking during aggressive courtship. Specific incidents of aggressive interchanges are described in Appendix C.

Greeting

Greeting exchanges consisted of animals joining each other to swim in unison, or joining accompanied by pectoral pats, body rubbing, or fluke pats. Joining of groups by individuals and merging of two or more groups occurred with high frequency in the nets. Adult spotter females sometimes joined adult males briefly and patted them, and vice versa. Many animals also moved from group to group, especially females and mother-baby pairs leaving and joining mother/young groups, and young adults in young adult groups (see Appendix B). Specific greeting episodes are described in Appendix B.

Rafting

The percentage of rafting animals ranged from over 50% in sets 3 and 4, to none, in set 10. Focal animals were observed in the rafting mode (066, 052), entering or leaving the rafting mode (019, 118, 119) and alternating rafting with other forms of behavior (018, 037, 038). In spotters, all categories of age and sex, and all subgroup types (including courting pairs) were observed rafting, at least intermittently. While the distinctions between subgroups are less easily made in stationary animals, subgroup cohesiveness could often be noted in groups moving into or out of the rafting mode. One large male rafted first with an adult

female, then cruised briefly and rafted again with a group of males (048).

Rafting animals were often very alert, in spite of their inactivity. In set 9 a juvenile spotter in a rafting group of juveniles rotated its body to inspect the observer. Rafting animals often permitted themselves to be touched or stroked, and while not showing avoidance, nevertheless made eye contact with the investigators and usually inspected the divers, during these episodes. In set 9, 10 rafting animals in a row tolerated stroking, showing no response other than visual inspection, but did not tolerate gentle restraint of the flukes, moving out of the rafting mode and away from the investigator when the flukes were held. More rafting animals were apparent in the water than could be seen from shipboard (set 6); but on all sets, after an initial period (c. 5 min.) of frequent breathing and post-chase agitation levels, neither an overall increase nor an overall decrease of the percentage of rafting animals in a school was noted.

Hovering and Sinking

Aside from rafting, two other forms of cessation of forward motion were observed: hovering and sinking. Hovering or hanging horizontal in normal swimming attitude, was recorded in 14 focal-animal cases: 8 adult male spotters,

and 6 females of mother-baby pairs. Eye movement during hovering was visible; each animal appeared to be inspecting another animal or an observer.

Sinking tail-first has been described as a precursor to the so-called "sleeping" or passive behavior, in which animals lie nearly motionless on the bottom of the net. No sleeping or passive behavior was observed by Pryor and Kang on this voyage. Vergne reported 2 animals lying on the net in the backdown channel in set 15. Brief episodes of sinking were observed during social interactions on five occasions (Appendix C). Sinking was often observed in intermittantly rafting animals. No animals were observed to sink more than 4 m. before returning to the surface or swimming away.

Sound Production

Both spinners and spotters produced a wide variety of sounds in the nets, consisting of whistling, echolocation click trains, and burst-pulse sounds. Burst-pulse sounds, sounding to the human ear like guttural coughs or snarls, were often noted (in nearby animals) to be accompanied by threat gestures. (In bottlenose porpoises burst pulse sounds are a major concomitant of aggressive interchanges (Gish, 1980)). Echolocation was indicated by short rapid scanning motions of the tip of the rostrum, both vertically and sidewise, the displacement from center of each movement

being about 5-10 cm. If the echolocation was aimed directly at the investigator the click-train sounds were sometimes perceivable and the source locatable. An extremely loud echolocation sound was used as a threat display by adult spotter males, directed at the observer. Echolocation was frequently heard and seen in the nets and was identified in 11 focal animal cases; all adults. Targets were the net (4 times), the tuna (1), an unidentified target (1), and the investigators (10). Echolocation was never accompanied by bubble production.

Both spotters and spinners whistled in the net, making a wide variety of bird-like sounds. Whistling animals sometimes produced a long, thin trail of bubbles from the blowhole while whistling. When following a whistling animal it was often possible to observe that the production of an intermittent whistling sound was accompanied by the simultaneous production of an interrupted trail of bubbles, or whistle-trail. Spinner schools produced more whistling (seemingly twice as many) and more bubble-trails (five-fold, est.) than most spotter schools. Rising plumes of whistle-trails from deep-swimming spinners were described as "forests of whistle-trails" in set 5. Overall incidence of whistle sounds and of whistle-trails varied from set to set. In set 12, with high levels of social activity, spotters whistled and produced abundant whistle-trails, "like spinners." In

set 6, a school which showed high levels of agitation (Table VI), just prior to backdown, a spotter school was described as "very noisy," with distress calls, and whistling audible in air, but only two whistle-trails were observed.

While the direction from which a whistle comes is difficult for human ears to discern underwater, loudly whistling animals nearby could usually be identified, and whistle-trails, when produced, assisted in locating source animals. Whistles and brief whistle-trails were produced abundantly by aggressively courting pairs, and by mothers and babies engaged in play interactions. Long whistle-trails (2 m.) were produced by solitary juveniles and by both mother and neonate in set 17.

The cacaphony of whistling in most sets put recognition of individual types of whistles beyond the capacities of the investigators; however it was noted that many whistle sounds were heard that had not been noticed from captive animals. The distress call, a rising and falling whistle typical of many species of cetaceans, was heard frequently prior to backdown in set 6, although no animals were observed to be in obvious difficulties and there was no mortality on this set. In set 7, distress calls were heard from an animal snagged in the net by a tooth, before it was released by Vergne. Nearby animals (3 m) evinced no reaction either to the distress calls or to the struggling of the entangled individual.

Bubble Displays

Six types of bubble formations were seen: the whistle-trail, balloon, balloon chain, cloud, torus, and simple air-release. Of these, only the whistle-trail, balloon, and simple air-release had been observed in animals in captivity. Balloons, moderate-sized, spherical clumps of bubbles (like basketballs), were released by apparently surprised animals, and were sometimes followed by a change of direction (127, 128, 129). A cloud, or large patch of bubbles (1 m. x 2 m.), was released by a male spotter during a status conflict in set 9; the defeated animal had disappeared when the cloud dissipated (photo).

The torus, a 'smoke-ring' configuration (c. .5 m. across) holding its form as it rises to the surface, was seen 5 times, once in emission by a male spotter in an aggressive encounter. Balloon chains, sets of evenly spaced balloons emitted by animals diving at a 45° angle, were seen by the senior investigator on a previous cruise in 1977 aboard M.V. Elizabeth C.J., once being emitted by a pair of animals simultaneously. (also described in Brower & Curtsinger 1979). Simple air-releases, of approximately the volume of a balloon but without shape, were seen in conjunction with burst-pulse threat displays three times, and in surfacing animals occasionally just before surfacing. The group of juveniles rafting head-downwards (070-075) all released air before surfacing on every respiration recorded.

"Pink Noses": Flushing of the Rostrum Tip

Just prior to backdown on several sets agitation levels of the schools rose; if the agitation level reached Level III, some adult animals observed from the surface were seen to have "pink noses," i.e., the white tip of the rostrum was flushed a rosy pink. This coloration was also seen in one individual at the beginning of a set, rapidly fading to white as the animal's degree of agitation fell from Level 3 to Level 1 (viz. Table III definitions). Pink noses appeared in association with bunching, chuffing, and porpoising, and were patently not due to abrasion but to increased circulation, as in flushing or blushing. ("Pinkening" of both rostrum and belly can be seen in bottlenose porpoises when water temperatures rise above 80°F).

Defecation and Digestion

Defecation trails, which, like whistle-trails, make long narrow plumes behind moving animals, were reported as extensive, "clouding the water," only in 2 sets, sets 4 and 12, a mid-day set and an early morning set. Only one focal animal was recorded as defecating during the observation period, an adult male spotter on set 4. In captive animals defecation occurs 3-5 hours after feeding. An adult female killed in set 12 was found to have the first stomach fully

packed with squid and flying fish of about 50-60 cm. in length, about half of each being partially digested and the other half of each being virtually fresh, suggesting two feeding periods, one shortly before the early morning set and one during the previous evening or night.

Aerial Behavior

Aerial behavior included running (long, racing leaps of many animals simultaneously, during the chase;) porpoising; spinning (in spinners); spotter display leaps; breaching; flips (both spotters and spinners); head slaps and tail slaps; spy-hops; and free-running (see Appendix A for definitions). Running, flips, spins, display leaps and porpoising were seen during the chase just after setting, just before back-down, but rarely during pursing and rolling. In set 16 several spinner babies were spinning repeatedly before rings-up. On set 17 before rings-up an adult spotter made ten leaps in a row, approximately 4 times its own body length above the water (c. 8 m.) turning in midair to re-enter the water head-first. Spyhopping is very brief in spinners and spotters (c. 1 sec.) but as in many other species can be related to the use of binocular vision in air (Pryor, 1975). Observations of nearby animals from the raft included two spy-hopping spotters looking into the raft, and one visually inspecting the fishing vessel.

Natural Tags

Natural tags included scars, damaged dorsal fins, and unusual colorations. Naturally tagged animals, once observed, were observed repeatedly throughout the set. Instances of naturally tagged animals are presented in Appendix C.

Sharks, Tuna, Other Organisms in Net

The most common non-mammalian large organisms in the net were adult yellowfin and skipjacktuna (Katsuonus pelamis). If adult yellowfin were present they usually approached the investigators immediately if the divers entered the water, and passed below them (2.5 m.) with eyes moving, apparently looking at the divers. This behavior was never repeated in a given set. Occasionally, large yellowfin would pass under, over, or behind the porpoise, either singly or together. During the progress of the sets, large tuna evinced increasing gaping of the mouth and erection of fins.

Skipjack, when observed, moved continuously, below or far from the porpoise. Interanimal distances in skipjack schools decreased from c. 1 m. to c. 1 body-width during the course of sets.

Porpoise were often seen to avoid tuna that approached them (007, 009, also sets 3,4,9,10). On set 9 a school of skipjack passed about 10 m. below a cruising mother-young

group. A small baby dived down toward them; its mother tailslapped and the baby returned to her flank (049,050).

Remoras (Remora sp.) were often seen, usually attached to babies. Several animals in sets 10, 12 and 14 were observed to have parasitic organisms attached to the trailing edge of fins or flukes. These organisms were brown, bottleshaped, about 4 cm. long, spaced at about 2 cm. intervals, and attached by a strong threadlike structure. Pryor attempted but was unable to remove one or more manually from a rafting spotter: the porpoise offered no resistance but the attachment organ of the parasite was too strong to break by hand.

Sharks were seen in the environs of the vessel and outside the net on several occasions. A shark was seen cruising within the net on set 2. Sharks came up in the braileron set 9 but were not observed in the water. On several sets tuna came up on the braillerwith evident shark bites, but no sharks were seen in the set or found in the brailler. All sharks seen by Pryor and Kang appeared to be oceanic whitetips (Charcharinus longimanus).

Flying fish were seen in the net occasionally. Tuna were reported as feeding on flying fish in the net (Ikehara et al., 1979), but no porpoise were observed reacting to flying fish.

A small (2 m. across) manta was observed several times during one set, and was gaffed and released during sacking up.

Invertebrate organisms observed included small plankton and salps.

Seabirds were frequently observed between and during chases, but rarely remained over the school after a set was made. In general, boobies and frigate birds were seen over spotter schools, and shearwaters over spinner schools, however no records were kept of bird sightings.

CONCLUSIONS AND DISCUSSION

Introduction

The research goals of this study, as stated in the introduction, were met, with the exception of following a school after backdown, which proved to be impracticable in the boats available.

In this study the focal animal sampling system proved to be extremely efficacious. Given the handicaps of having to observe large groups of animals for periods of less than an hour, under physically demanding circumstances and with no opportunity to observe those same animals at a later date, this system allowed us to make some sense of the behavior of individual animals, to acquire some quantifiable data for comparative purposes, to ascertain the nature of subgroup formations at least in spotters, and to develop some hypotheses about overall school structure.

In addition, focal animal studies and general observations provided insight into learned behavior, levels of stress and/or agitation, and some previously unobserved behavioral events. The data also suggest answers to some of the questions listed in the introduction, such as a possible system for neonate transport.

School Structure:
A "Tribe" Hypothesis

The data suggest that subgroups identified in spotters do not operate independently of each other, but are linked into larger groupings which are socially affiliated and probably at least to some degree genetically related (Perrin, 1969), groupings which we shall call tribes. Captive observations show that porpoises are unlikely to engage in social interaction with individuals previously unknown to them, showing avoidance or aggression to strangers; this is especially true of the small, pelagic species, such as spotters, spinners, and common dolphins, which may avoid a new individual in the tank for several days (Pryor, 1975, Evans, pers. comm.). Therefore animals in the nets which swim in the same subgroups may be assumed to be well acquainted with each other. Separate subgroups which swim near each other may also be assumed to recognize each other as individuals. The wide occurrence of greetings, joinings, partings and rejoinings between representatives of all classes of animals, males and females, young adults, juveniles, and mothers and young, observed in all sets seen under water, further reinforces the hypothesis that spotters, at least, are organized into aggregations in which all ages and sexes are represented, and which remain relatively stable over a period of time. Four other observations also support this hypothesis. First,

every school, even the 23 animals in set 1, contained all 5 kinds of basic subgroups. Second, whenever we could get a close look at groups of 50+ animals escaping across the bows, these groups contained babies, young, juveniles, and small and large adults. Third, several sets were observed to contain large (30+) groups of animals of the same species which did not mingle, as in set 9, which contained two groups of spotters and three of spinners. Fourth, in large schools, where we remained in one quadrant of the school, so did those animals which we could recognize by marks and scars. Finally, the division of large aggregations into groups of 30 to 200 or so which behave independently of other such groups is commonplace during the chase.

We suggest that the large aggregations of thousands of individuals, seen in both spotters and spinners, are actually associations of tribes, consisting of related subgroups, and that these tribes are organized, at least in spotters, around the dominant male subgroups. These subgroups make no apparent effort either to lead or to herd other animals, and may be found in any part of the school. At backdown, dominant males may go out of the net together, but in no particular order vis-a-vis other subgroups. However, the events in set 17, in which a speedboat frightened the school, strike us as illuminating. Two different dominant male subgroups, on which each of us were doing cases at the time, were abruptly surrounded, in close,

bunched formation, by mother-young, juvenile, and young adult subgroups, which swam in unison with the males until the alarm response died down. It would seem likely that during a chase, dominant male subgroups execute whatever evasive maneuvers they may have learned, and that, far from escaping on their own, they are closely accompanied by their own associated females, off-spring, and young adults. Thus, the genetic continuity observed by Perrin in individual schools would be maintained, with any "trading" between tribes probably occurring at the age level of the loosely-associated young adults. Furthermore, the whole school or tribe thus benefits from the acquired experience of the oldest males.

A single tribe might contain several dominant male subgroups; eight were counted in one cohesive school of about 220 animals. Observations were made of dominant male subgroups which accepted each other's presence without visible aggression, dominance disputes presumably having been settled, and of dominant male subgroups which clashed vigorously upon meeting each other; perhaps these were subgroups from different tribes.

The upper limits of tribe size may be related, as in many primates, to the maximum number of individuals which can be recognized and remembered; a tribe which grew beyond this size, perhaps 200-300 animals, would experience increased levels of aggressive encounters and would presumably split up, different portions of it following different dominant male

subgroups. Also, of course, tribes may join in large-scale aggregations or schools, and swim with a variety of other tribes, without actually mingling, as in set 9.

A similar picture has been presented for the Black Sea bottlenose (Bel'kovich et al, 1978). Three years of observation (omitting the winter months) of coastal bottlenose porpoise revealed that basic subgroups of 2-5 animals, changing composition somewhat as calves matured, were associated into herds of up to 20 animals, comparable to spotter tribes. The piece of coastline under study by Bel'kovich contained three such herds, comprising a resident population, which only rarely aggregated into a large group, called by him a shoal, perhaps comparable to some large spotter schools (300-1,000 or more). There is no evidence for dominant male subgroups in bottlenose porpoise herds, in which the dominant position is usually held by a single individual, often a female; but the mechanism of social organization may be similar.

The behavior of small pelagic porpoises differs in many ways from that of the more familiar bottlenose (Pryor, 1973; Pryor, 1975; Pryor and Norris, 1978; Defran and Pryor, 1980). The existence of the dominant male subgroups seen in spotters, and occasionally identified in spinners, seems to have no exact terrestrial parallel. In baboons, aging males may form alliances to defend each other against mature males, and thus maintain dominance; in spotters, however,

it is the mature males which form tight associations, performing many acts, including threat displays, as a unit; the "dominant animal" seems to be not an individual but a unified group. The conspicuously flashmarked white rostrum tips of these males can be seen at a distance, like flash-lights travelling in formation, sometimes long before the animals themselves become visible. These subgroups may even attack in formation with a precise simultaneity that seems almost eerie to the human observer (Coe, pers. comm.; Brower, and Curtsinger, 1979). Presumably this unusual social adaptation facilitates defense of the school and promotes survivability on the "tribe" level. Given this picture of social organization, it seems highly unlikely that animals which escape the nets are ever stratified according to age, e.g., all dominant males, or all non-reproducing young adults, an idea which has caused concern (Southwest Fisheries Center Report No. LJ-79-41, 1979).

Learned Behavior and Stress

Two of the original research goals appeared to us to be interrelated: levels of learned behavior or adaptation to the fishing procedure, and levels of stress and agitation in the nets. The evidences of learned evasive techniques during the chase have been more fully reported on by others (Norris et al, 1979, Stuntz and Perrin, 1979, Vergne, 1979) and it is generally agreed that throughout the area

of this fishery, over the course of years, schools have developed increasing skill at evading the chase and the set. It also seemed apparent to us that, once a set was made, schools had developed learned or adaptive behavior for coping with being in the net. All schools seen by us adopted the same station in the net, as far from the ship as possible, but often close to the net. Norris et al observed that the animals also avoided the net, and considered that the stationing occurred in a sort of mode of fear-reduction, as far from the ship as possible while still being as far from the net as possible. Our observations in approximately the same waters two years later showed much closer approach to the net, often within a few meters, and on some occasions the school halted in the appropriate spot before the net was set. Prompt gathering at the backdown area, and low levels of agitation in that area in some sets, despite intensive crowding and the very close presence of the net, also suggested habituation. In all except set 6, (a spotter school) animals appeared to anticipate the lowering of the corkline, and to respond to it, either by swimming or even clambering over the corkline, or by waiting, often with tails to the corks, until the line passed beneath, and then turning and free-running.

The abundance and wide variety of social activities in the nets also indicated to us that the animals were

previously experienced, and in the absence of unusual events (such as incursions of the net or circling of nearby speed-boats) were not experiencing significant levels of fear, but were "going about their business" in a relatively unstressed way. Furthermore the behavior of rafting, or hanging motionless in the water, appeared to us to have some learned components in many animals. Certainly rafting, or intermittent rafting accompanied by whistling and sinking episodes, was associated with other symptoms of stress in some animals, especially juveniles and young females with babies. Many rafting animals however gave evidences of both alertness and lack of agitation. It seems at least possible that what began as stress reaction, perhaps cessation of swimming because there seems to be no safe place to go, has become adaptive: one way to avoid getting into trouble in the nets is to stay away from the net and remain in one place.

The lack of overall signs of stress and distress was in fact surprising to us, and somewhat in contrast to reports of previous observers in 1976 or prior years. Although focal animals were chosen over a wide range of active and inactive animals, very few remained in Level III agitated states even for 5 minutes (Table IX) and many of those in Level II were socially agitated rather than in stress states. Older animals, whether solitary or in groups, were almost always calm; only once did we see a solitary animal (an adult male spotter)

"lashing out in all directions," as described by Norris (Norris, et al, 1979) nor did we see heightened aggression in the pre-backdown period, with sideswiping and charging, except in set 6. In fact aggression and other forms of social interaction usually disappeared prior to backdown. Direct comparison with data in Norris et al, 1979 is difficult, since both terminology and data acquisition systems differ, but it seems apparent that in spotter schools between release of the net skiff and rings-up the 1976 observers saw far more breaching, fluking, headslaps and other aerial activity that we did, except on set 6, during this period, suggesting whole-school agitation levels of III and IV in most schools they observed. If schools can acquire learned evasive techniques exhibited during the chase, as they evidently have done (Stuntz and Perrin, 1979), it seems possible that schools may also be developing adaptive or learned behavior within the net, which in addition to declining incidence of entanglement should contribute to reduction of levels of agitation and overall stress. In set 6, in which agitation levels were high throughout the set (totalling 13, compared to the next highest total of 9 points, a minimum of 3, and an average of 6.3) other evidences such as incompetence at going out of the net also indicate that this school may have been less experienced than the other schools we saw, and more comparable to most of the schools seen on the Elizabeth C.J. behavioral cruise.

Three episodes previously described seem to us to be striking evidences of learned behavior in a way not so much because of what the porpoises did as because of what they did not do. The porpoises that crowded around the raft in set 2 were started at a sudden armwave, but did not move away. They were not startled however by the raft, its passengers, or any other activity of the passengers, suggesting familiarity with rafts and passengers. A second incident involved the female in the backdown area which three times knocked her baby into the air, thus effectively subduing its behavior of rushing about while close to the net; similar "reprimanding" has been observed in baboons whose infants stray dangerously (Tayler and Saayman, 1971) and porpoises of several species in captivity; the implication is that the female was aware of the hazard of the infant's behavior. Finally, in set 10 while the school was closely gathered in the backdown area, two observers, one on the ship and one at the backdown channel, saw a group of 6-8 unusually large, dark animals, probably a dominant male subgroup, leave the school and travel rapidly back towards the ship, where they circled closely around an apparatus which was being withdrawn, by raft, from the depths of the net. The group then returned to the school equally as swiftly (Appendix B). This in our experience anomalous event, which resembled investigative behavior seen in captive animals, was interesting evidence

of one of the possible functions of senior male subgroups, but also may indicate a) that the animals were sufficiently free from distress, even just before backdown, to exhibit curiosity and carry out investigation, even approaching the ship to do so, and b) that the apparatus (fish attractant equipment consisting of floats and tubes) was sufficiently unfamiliar-looking to warrant investigation; therefore other objects that are normally in the net are not unfamiliar.

There is no quantitative evidence on how often each school may be recaptured in a year, but it is generally agreed that many schools are set upon repeatedly, from an estimated dozens to hundreds of times in some areas, giving at least the older animals ample opportunity to adapt appropriately to the procedure. We surmise that both within and without the CYRA, and given the rise in improved techniques and the reduction in mortality, with "zero-kill" sets now averaging 75%, opportunities for learning have been excellent, and that behavioral adaptation by the porpoises themselves may be a significant contributing factor to lowered stress levels and lowered mortality in the nets.

The effect of the chase and setting, in summary, does not seem to disrupt the social structure of the school. With the exception of an occasional juvenile swimming alone, whistling repeatedly, and appearing to be searching, solitary animals usually joined others in less than five minutes, and there were abundant evidences that animals in the nets were in long-established, well-structured associations with the

animals around them. Juveniles, recently weaned, and less experienced, might well be the animals most easily parted from their juvenile subgroups. Nor did we see those evidences of exhaustion or extreme stress or distress known to us in captive animals, either in adults or infants, but rather, in babies a tendency to play, and in adults, at least in morning sets, to engage in social interaction.

Adult Male-Female Ratios

Mortality studies indicate that 2-3% more adult females than males are entangled in the nets, suggesting that females are more vulnerable, that schools contain more adult females than males, or both (Perrin 1976). Whole-school studies aboard the Dedicated Vessel, in which all animals within the net were sexed and measured before release, also give clear evidence of a higher proportion of females to males (Coe et al, 1979). If further studies do reveal a reduction in the proportion of adult males to females this may be a reflection of status conflicts among males. Both in captivity and in the nets we observed males in aggressive interactions striking each other with severe ramming blows amidships, blows which in captive animals sometimes left permanent scar tissue. A study of porpoise skeletons in European museums revealed healed rib and vertebra fractures in many cases, which could certainly be caused by such blows

(de Smet, 1977). Blows severe enough to cause scarring and fractures may at least occasionally be fatal. A reduction in numbers of males may occur at sexual maturity, due to aggression by older males; prolonged aggressive exchanges observed by us in spotters always involved a dominant male (fused coloration) and a younger male (mottled or speckled coloration).

Transport of Neonates

Another matter of concern has been the falling-behind and possible loss of very young animals. Since in times of alarm the dominant male subgroups are seen to form the center of a cluster of animals, it is possible that while the direction of travel depends on the males, the speed of travel depends upon how fast the cluster can go, and that the whole group slows as fatigue becomes a factor. Neonates, however, based on observations of captive animals, swim very weakly during the first days of life, and could hardly be expected to keep up at any speed. Kenneth Norris observed that neonate spinners in the wild do not appear to swim actively at all when positioned next to their mother's dorsal fin (Norris, pers. comm.). Two spotter neonates were observed by us on this cruise, identifiable by the presence of fetal folds and remnants of the umbilicus, both of which disappear within two weeks after birth in captive spinners (that only two were seen, and on the

last set, is probably due to improvement in our observation skills, not to an absence of neonates previously). Indeed, the neonates were not observed to move their tails at all, except for a flutter when surfacing to breathe, though both mothers were swimming quite rapidly throughout the set. Erich Klinghammer has offered an explanation for this phenomenon (Klinghammer, pers. comm.). The Bernouilli principle states that a gas or fluid moving through a constricted space will speed up, causing suction (as when a truck closely passes a car on the highway). Therefore, if a female swims fast enough to create suction between her body and that of the infant sufficient to overcome the infant's resistance to the water, the infant will be carried along with her; perhaps this is one reason why the females with neonates we saw were swimming rapidly. As the infant grows, of course, a point of no return is reached, which may account for triads, in which small but not neonate babies are carried closely between two adults, the Bernouilli effect this being increased.

Also this hypothesized requirement for the presence of two animals in transportation of post-neonate babies, during episodes of fast swimming, suggests an adaptive value for the presence of the post-reproductive females which occur in spotter schools (Perrin et al, 1976). The altruistic behavior that has in some other species been dubbed "aunting"

might here be a true physical necessity. While some triads contained a male adult, most consisted of a speckled or mottled female, a baby, and an older heavily mottled or fused female. Mother/young subgroups also sometimes contained one fused-pattern large adult female without young. It may be that in spotters at least, as in elephants (Douglas-Hamilton 1975) mothers continue to associate with their daughters and with the daughters' young, throughout life, providing crucial altruistic support.

Effect of Time of Day on Behavior

Neither rafting nor vertical columning appeared to be correlated in any statistically significant way with time of day. School agitation levels also did not correlate with time of day (Table VII).

Social behavior levels however did vary according to time of day. All spotter schools actively engaged in extensive social behavior were seen before noon; the three schools observed underwater in the afternoon were quiescent. It seems possible that spotters are crepuscular feeders, hunting at dawn or in the early morning and again at dusk (the single sample from a female with two separate meals in her stomach supports this). A period of heightened social behavior, at least in daylight, might follow after a period of feeding, as described for the dusky dolphin, (Lagenorhynchus obscurus) (Wuersig, 1978).

Specific Behavioral Events:
Visual and Echolocation Targets,
Rostral Flushing, Bubble Displays

A few individual behavioral events and observations justify further discussion: first, our recognition of visual and echolocation targets. Unlike many land animals (e.g. the horse, the goat) the porpoise's eye focuses sharply and in a manner which is recognizeable to a human observer. Porpoises often make direct eye contact with people, even through a face-plate (this recognizeable eye contact is probably one characteristic which endears the animals to the public). One can also judge, with experience, what a porpoise is looking at, whether with one eye, using lateral vision, or with both, using binocular vision, (as when spyhopping, or when an animal visually inspects an investigator swimming underneath it). Although porpoises have good vision (Herman, 1977) the clearly directed glance need not be related to visual acuity; one can, however, imagine an adaptive advantage to this recognizeable focusing in animals which swim literally eye to eye, and undoubtedly make eye contact with each other. The directed focus could communicate such matters as recognition or, in an aggressive animal, against which individual in the group the aggression might be specifically intended.

Echolocation targets can often be deduced by watching a scanning animal. The sonic beam is so narrow (Ivanenko et al, 1978) that one can tell, if the target is within

10 m. or so, what the animal is aiming at by its orientation, as one can usually tell what a person is pointing at. Echolocation is brought into play, in our opinion, only when visual inspection will not suffice, either because visibility is poor or perhaps because the target is an unfamiliar object. We often saw animals echolocating on ourselves, but rarely on each other.

"Pink noses", or the flushing of rostrum tips during some periods of heightened agitation, have been thought by fishermen to be caused by abrasion, as have the whitened rostrum tips of large adult animals, even when not flushed. On close observation these can be seen to be natural colorations, the pinkness occurring, in our observations, when the animals were in an excited or anticipatory state, usually just before release (comparable perhaps to the flared and sometimes reddened nostrils of a horse anticipating sudden activity).

Finally, we found the ability of spotter porpoises to emit shaped patterns of bubbles of great interest and worthy of further study. Conspicuous behavior with a high degree of stereotypicity is the hallmark, to ethologists, of social signalling behavior; bubbles are of course highly detectable not only by eye but by sonar and the bubble patterns

differed widely from each other but were each stereotypic from animal to animal. The fact that we ourselves gained information from bubble-patterns (long whistle-trails identifying the source of nearby loud whistles; a torus indicating the location of an aggressive encounter, etc.) suggests that the animals certainly can do the same. Bubble patterns may form a method of social signalling that is used by many cetacean species; and this is a prime example of behavior that can only be observed and studied underwater.

Comparative Values of Observations
In Captivity, In The Nets, And In
The Wild

While it is sometimes held that observation of animals in captivity is not a suitable basis for observation of animals in the wild, we found that our experience with spotters and spinners in captivity was fundamental to observation in the nets. Virtually all of the behavioral events occurring in the individuals, or between individuals, were well-known to us from captive animals, the exceptions being some mother-baby interactions, some bubble displays, and some apparently stress-related behavior. Our familiarity with individual behavioral patterns, as evidenced by the preparation of a very adequate "dictionary" before going to sea, allowed us to identify actions which might be indecipherable to a novice observer, such as gaping

(a threat display often anthropomorphically misinterpreted as "smiling" by laymen) and to notice small movements, such as scanning, which might be overlooked were they not already known to have significance.

It is our impression that observation of captive animals allows good interpretation of individual behavior, but does not allow a clear picture of subgroup behavior, since animals are not kept in captivity in large enough groups to allow representative subgroup formation. Observations in the nets are necessarily somewhat different from observations of free schools, since the animals are chased and confined, which might be expected to alter their behavior. Most obviously, in free schools of these species all animals are usually oriented in the same direction, and travelling forward, while in the nets the animals are circling, diving, and travelling in various directions, or hanging motionless. Also interanimal distances both within subgroups and between subgroups seem to be much larger in unconfined schools. However, comparisons of our observations in the nets with films, photographs, and personal underwater observations of spotters and spinners in the wild persuade us that the next level of organization above individual reactions, namely the behavior of subgroups and the interactions between subgroups, can indeed be observed clearly in the nets, and is comparable to subgroup organization and behavior in the wild. The organization and behavior of tribes or whole schools, and the

interaction between tribes, presumably requires study of free schools in their natural habitat.

Future Research

As to be expected, many questions were raised by this study which one hopes will be addressed in future research:

1. Relationship of porpoise to tuna. The tuna-porpoise relationship may at least in part be a feeding association in which tuna follow porpoise for their superior food-locating ability (Norris 1978).* A bottlenosed porpoise can locate a 20 cm sphere 2 km away by echolocation, perhaps further than a tuna could locate prey by chemoreception or vision (Ivanenko et al, 1978). Tuna are swifter and more maneuverable than porpoise, and the porpoise could not escape the tuna if they wished to; it was noticeable in the net that porpoise avoided any tuna that came near. Further comparisons of stomach contents, with regard to digestive state in same-set animals, as well as contents, might be illuminating, as might also be underwater behavioral observations of tuna-porpoise schools, perhaps off Costa Rica where schools are once again observable.

*The association also appears to include other organisms, especially marlin, small sharks, and several species of birds.

2. Quantification of subgroups in schools. While diving in the nets is hazardous, it is feasible, and observations made underwater are vastly more informative than those made from the surface. Once subgroups become recognizeable, it should be possible, at least in small schools, to identify and count all the subgroups, thus making "whole-school" sex and age surveys possible without handling of individual animals. This would contribute quantified data to studies of population dynamics and reproductive status of species.

3. Comparison of spotter behavior and social structure to that of other species, especially the white-belly porpoise, or common dolphin. This species, also involved in the tuna-porpoise fishery, is the least well-known of the three involved species, behaviorally, and in 1979 accounted for 25% of the mortality. Focal animal sampling studies should be made on this species. Comparison of both individual behavior (as given in Appendix A) and group behavior and structure might lead to both a better understanding of this species and to improved handling in the nets. Further studies of spinners are also desirable, and might show ways in which they do or do not resemble spotters behaviorally.

4. Confirmation of subgroup structure and relationships in unconfined spotter schools. Preliminary evidence shows that there are accessible schools of spotters in

several locations, which might be observed repeatedly over a period of days or weeks, in which individuals can be recognized and subgroup formations occur. Field study of such a school, underwater, including filming, would do much to confirm the findings of this report, to pin down continuity of relationships over time, and to elucidate details of the life cycle of this species. A proposal for such a study, of a school or schools in Hawaii, and of their associated yellowfin tuna, is in preparation by the authors.

5. Reduction of canopies. While much adaptive learning has taken place, animals which become canopied are still at a serious disadvantage. They are physically incapable of swimming backwards. The need for air causes them to fight upwards against the net. Even if open water is available a few feet away, the upward struggle prevents the animal from experiencing escape through turning and swimming elsewhere; thus the animals are restricted, by their own behavior, from learning to evade canopies. Present net technology studies aimed at reducing or eliminating canopies and stern sway are certainly of direct benefit to mortality reduction.

6. Tagging studies. One form of surface study that contributes excellent information not available in any other way is tagging, both by radio-tracking and dorsal markers.

Relationships between animals, cohesiveness or lack of cohesiveness of schools, and migratory travel can all be investigated through tagging. Of particular importance are the degree of mixing between stocks, and stock distribution. We would advocate continued radio tag and marker design development and extension of tagging programs.

7. Age discrimination studies. Present age discrimination methods, based on tooth-ring counts, do not discriminate age in animals above twelve years in a satisfactory way. Captive observations and other data suggest that porpoises live at least 20 years, and possibly much longer. The lack of information about age distribution in animals older than twelve, which may form a sizeable portion of the reproductive population, impedes the accurate assessment of reproductive fitness of the populations, an assessment vital to the establishment of quotas and other management procedures. Tetracycline staining and other methods of improving age discriminations should be further pursued.

8. Basic behavioral work. Further underwater observations might be directed especially towards behavioral events not previously known, such as some bubble displays; to links between acoustic behavior and social behavior; and to other aspects of individual behavior not presently well understood.

The study reported on here was necessarily largely descriptive in nature, preliminary, and exploratory. It is our hope that others will be able to build on this work, to extend it, and to find in it new avenues of approach to increase our understanding not only of the porpoises found in the tuna-porpoise fisheries, but of cetacean behavior and ecology in general, up to and including the great whales.

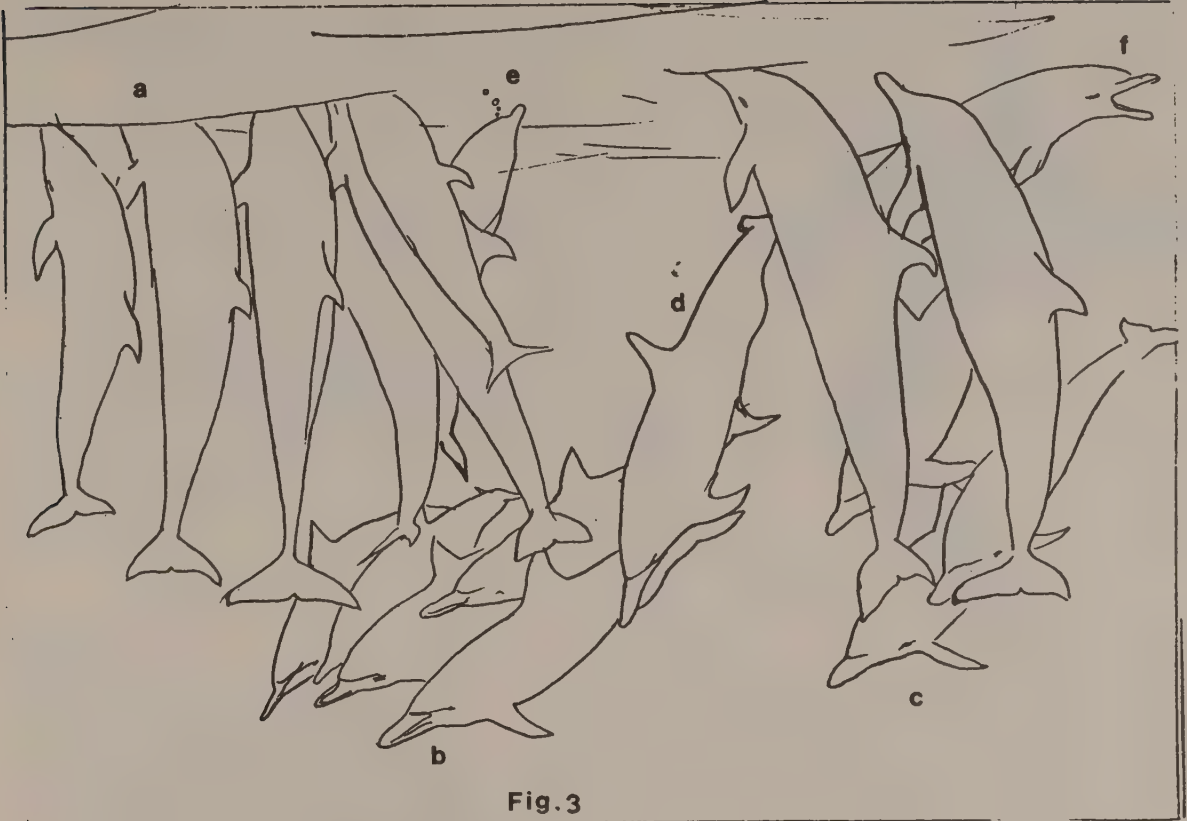


Fig.3

Figure 3. Rafting and cruising spotter porpoises.
 a, b: mother-young groups, identifiable by presence of smaller animals; c: three young adults; d: adult male (note keel bulge; e: whistle-trail; f: gape, threat display.



Fig.4

Fig. 4. Mother-young subgroup. Note close interanimal distances, presence of smaller animals, positional fluidity.



Fig.5

Fig. 5, left: Mother-baby play, spotters. Baby rubs dorsal fin against mother's pectoral fin.

Figs. 6, 7: Transportation of young.

Fig. 6, left: Spotter triad. Two adult female spotters with baby (approx. 3 mos.) between them.

Fig. 7, right: Female spotter with neonate (note fetal folds) in transport position while diving. Neonate makes no swimming motions. Note simultaneous long whistle trails.



Fig.6

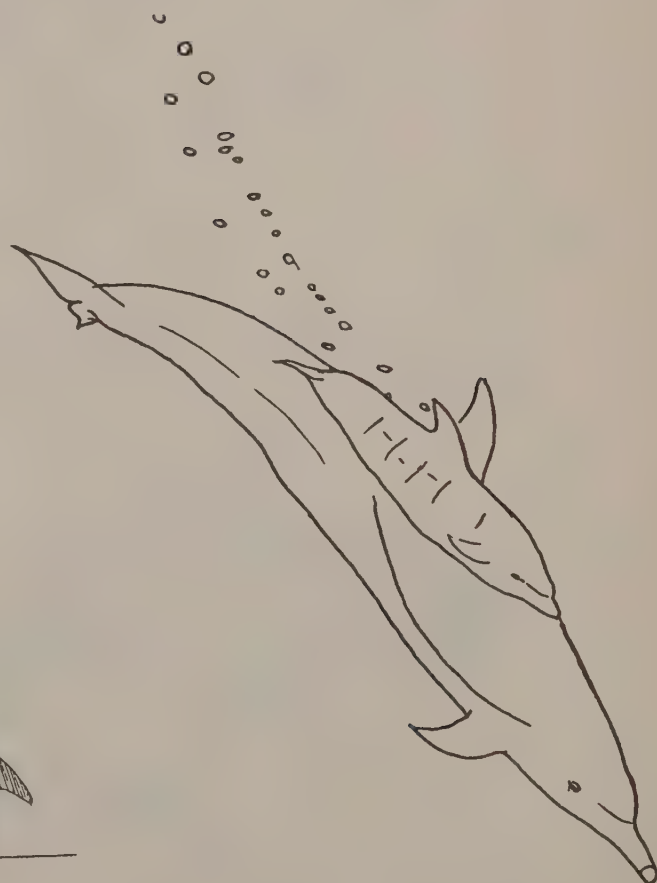


Fig.7



Fig. 8

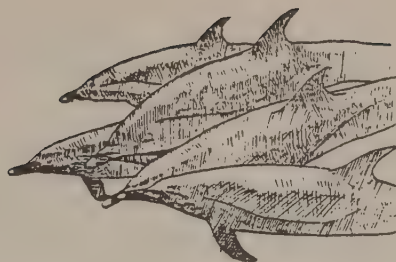


Fig. 9



Fig. 10

Fig. 8, top left: Solitary juvenile spotter emitting interrupted whistle and whistle-trail.

Fig. 9, top right. Dominant male subgroup, spotter, being threatened by surfacing male. Note typical close synchronous swimming formation and white rostrum tips.

Fig. 10, center. Aggressive courtship. Male, right, is toothraking.

Fig. 11, below. Juvenile spotters rafting heads down. (See text, p. 44, and App. B p. 4; a seldom-observed but persistent behavior, possibly stress-related.)



Fig. 11

Illustrations by Michael Pryor from photographs taken by Karen Pryor, within the net, on sets 7, 10, 12 and 17.

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APPENDICES

Computer Code	Name of Behavior	Description	In Captivity		In Nets	
			Spotter	Spinner	Spotter	Spinner
	<i>GENERAL</i>					
RF 1	Rafting, head up	Hanging near vertical with head at surface			4	
RF 2	Rafting head downwards	Hanging motionless, near vertical, head down			4	4
ML	Milling	Whole school swimming about in one area			4	4
DV	Dive	Descends from surface head first	4	4	4	4
BR 1	Breathing	Normal respiration	4	4	4	4
BR 2	Chuffing	Sharp, puffing exhalation: alarm	4	4	4	4
BR 3	Splash-breathing	Chopping at surface to get a breath, in chase: fatigue			4	4
SW	Swim fast	Speed up in comparison to other animals; may be fear, play, other	4	4	4	4
JN 1-7	Join another	1=adult, 2=baby, 3=pair, 4=small group 5=large group, 6=juvenile, 7=mother/baby	4	4	4	4
BJ 1-7	Be joined by	Same code as above	4	4	4	4
LV 1, 2	Leave	1=animal leaves other, 2=is left by	4	4	4	4
HV	Hover	Hang motionless, horizontal in water in normal swimming attitude	4	4	4	4
BB 1	Whistle trail	"Contrail" of bubbles from blowhole; coincides with whistling	4	4	4	4
BB 2	Balloon	Basketball-sized sphere of bubbles from blowhole. Sometimes indicates surprise	4	4	4	4

APPENDIX A Continued

Computer Code	Name of Behavior		Description	In Captivity		In Nets	
	GENERAL, CONTINUED			Spotter	Spinner	Spotter	Spinner
BB3	Balloon series		Animal releases several evenly-spaced balloons			11 *	
BB 4	Unison balloon series		Pair of animals release series in unison			11 *	
No code	Torus		Animal releases perfect "smoke ring" of bubbles about a foot in diameter			11	
No code	Cloud		Animal releases huge clouds of bubbles; may duck behind them and disappear			11	
A 1-9	Zap; echolocate		Click train emitted; indicated by small multidirectional movements of tip of jaw	11	12	11	12
			1=at person, 2=at other porpoise, 3=at net, 4=at tuna, 9=other				
DF	Defecate		Clouds of fecal matter released	11	12	11	11
TU	Tuna nearby					11	11
SH	Shark nearby		Not observed				
HD	Nodding		Rapid up and down head movements	11	11	11	11
PN	Pink noses		White tip of rostrum turns rosy: excitement or exertion			12	
MS 1	Miscellaneous		Shakes whole body slowly from side to side			11	

APPENDIX A Continued

Computer Code	Name of Behavior		Description	In Captivity		In Nets	
	FEAR AND DISORIENTATION			Spotter	Spinner	Spotter	Spinner
BR2	Chuffing		See "General" category				
EY	Show eyewhites		Rolling eyes, like frightened horse	41	42		
TR	Tremble		Quiver in fear: sometimes pre-shock	43	44		
TT	Teeth chattering		Fear behavior, as in many mammals	45			
BU	Bunching		Draw into tight packs, swim in unison	46	47	48	49
DS	Distress call		Rising and falling whistle emitted when animal is entangled or in other difficulty	49	48	49	49
WS	Loud whistling		Loud whistles other than distress call	49	41	42	43
PA	Panic		Animal dashes blindly about	49	48	49	
SG	Struggle		Trapped or entangled animal thrashes about	49	48	49	
FL	Flight		Animal flees at full speed (observed during chase but not in net)	49	48		
FE 1	Startle		Flinches at sudden move or noise	49	41	42	43
VE	Vertical bobbing		Animal hangs vertically, rising and falling	49	47	48	49
SK	Sinking		Sinking tail first	49	46	47	48
BA	Off balance		Animal flounders, falls sideways, may ship water in blowhole: extreme stress	49	48		

APPENDIX A Continued

A-4

Computer Code	Name of Behavior <i>FEAR AND DISORIENTATION CONT.</i>	Description	In Captivity		In Nets	
			Spotter	Spinner	Spotter	Spinner
LY	Lying on bottom	Animal sinks to bottom and stays there; in captivity, reaction to frustration		4b		
JS	Jostling	Normal "manners" are not maintained: animal bumps into or jostles others	4b	7a	7b	4b
EH	Entanglement	Trapped in a line or in netting	6c	2c	4b	
DB 1	Disoriented "lost baby"	Spotter young: animal twirls vertically below school, whistling loudly			6a	
AV 1-6	Avoidance	1=porpoise	4b	6c	6c	4b
		2=person	4b	6c	6c	4b
		3=boat	4b	4b	6a	4b
		4=net	7a	7a	6c	4b
		5=wake			6c	4b
		6=tuna (or other fish)	4b		4b	4b
		9=other	4b	4b		
	<i>SURFACE AND AERIAL BEHAVIOR</i>					
TS	Tailslap	Slaps ventral surface of tail on water; irritation, annoyance, alarm, warning	4b	4b	6a	4b
HD	Headslap	Slaps head on water: usually laterally in these species: annoyance-impatience	4b	4b	6a	4b
BC	Breach	Slaps whole body sideways on water	4b	6a	6c	4b

APPENDIX A Continued

Computer Code	Name of Behavior <i>SURFACE AND AERIAL CONT.</i>	Description	In Captivity		In Nets	
			Spotter	Spinner	Spotter	Spinner
SP	Spin	Animal spins in the air on its long ^{short} axis; species-typical behavior		2		4
FL	Flip	Flips tail over head in air	3	4	4	
PR	Porpoising	Arcing roll or leap at surface	4	6	4	4
TW	Tail wave	Waves tail stock back and forth in air			4	2
SB 1	Surface behavior: fluking	Animal shows flukes in air before diving	4	4	4	4
HP	Spyhop	Sticks head out of water and looks around in air; usually very brief in these species	4	4	4	4
RU	Running	Long, low, racing leaps of animals traveling at top speed; many leap at once	4	4	4	4
llo code	Free-running	High, popping individual leaps, with big splashes, after leaving net			4	4
No code	Spotter display leap	Species-typical high leap, body in an S-curve traveling horizontal to water, 15 feet or more	4		2	
No code	High porpoise	Animal leaps straight up, rotates at top of jump, re-enters "same hole it came out of"	2	4	4	
No code	Unison behavior	Most of the above maneuvers may be carried out by two animals in unison	4	4	4	4
TH	AGGRESSION					
	Threat sounds	Burst-pulse			4	
		Loud click train	4	4	4	2
SN 1,2	Sniffing	Sharp sideways jerk with closed or open jaws; may be accompanied by sound	4	4	4	4

APPENDIX A Continued

A-6

Computer Code	Name of Behavior	Description	In Captivity		In Nets	
			Spotter	Spinner	Spotter	Spinner
W 1-6	Jaw movements	Doer: 1=gape, 2=snap receiver 4=gaped at, 5=snapped at	4	4	4	4
		3=bite, 6=bitten				
T 1-4	Strike	1=with pectoral	4	4		
		2=with dorsal fin	4	4		
		3=with rostrum	4	4		4
		4=with flukes	4	4	4	4
H	Chase	One or several animals may chase another, or two animals may chase each other	4	4	4	4
G 1,2	Charge	A head-on rush as if to ram	4	4	4	
A	Ramming	Hit another animal amidships full force, head-on	4	4		4
lo code	Fighting	Extended exchange of blows or attacks between two or more animals (always males)	4	4	4	4
lo code	Attack or strike baby	The mother herself, or other adults, may strike a baby very hard	4	4		4
	AFFILIATIVE AND SEXUAL					
H	Hold hands	Swims with pectoral fins overlapping	4	4		4 **
E 1,2	Pectoral pat	Pat or stroke with pectoral 1=doer, 2=rec.	4	4	4	4
U 1,2	Fluke pat	Touch or stroke with flukes 1=doer, 2=rec.	4	4	4	4

APPENDIX A Continued

A-7

Computer Code	Name of Behavior	Description	In Captivity		In Nets	
			Spotter	Spinner	Spotter	Spinner
PU 1,2,3	Push	Pushes another animal with head or rostrum	4	4	4	4
NU	Nursing			4	4 *	
BG 1,2	Beak-genital propulsion	Subordinate animal places rostrum against vent of superior animal and pushes it along	4	4	4 *	4
CT 1	Touch heads	Two animals hover face to face and touch or rub heads or rostrums; "kissing."				
CT 2	Gentle mouthing	Usually baby to mother				
RB 1,2	Rub bodies	Two animals slide against each other, rubbing flank or belly on the other	4	4	4	4
PP	Chasing in pairs	Sexual play: fast, looping chases	4	4		4 **
CH 3,4	Play-chase	Mock chasing, with reversals; mother/baby and juvenile play	4	4	4	
PT	Prostrate	One animal prostrates itself across another's rostrum: submissive display	4	4		
PC	Position for copulating	Male inverts himself below female	4	4		
CP	Copulation		4	4		4 **
RK 1,2	Tooth-raking	One animal draws its teeth across body of the other, leaving parallel scratches	4	4	4	4
WH 1-3	Where on body	Code indicator for where raking occurred: 1=head, 2=tailstock, 3=vent				
WH 4	Raking gesture	Moving head, jaws open, back and forth in the water as if to rake				
No code	Protect or assist	Usually mother to baby; adult to adult observed in one spotter in captivity	4	4	4	4

APPENDIX B

Subgroup Behavioral Events

1. Senior male squads (for aggressive and greeting incidents see Appendix C)

Behavioral events reported in spotter senior male squads included:

Joining mother-young groups

Being joined by mother-young groups (also spinners)

Swimming deep below school

Swimming around perimeter of school

Single animal detaches itself from squad and hovers, broadside to both group and investigator, eyeing investigator with the near eye (a common sight at the beginning of most dives)

Several large males leave school just before back-down, and swim rapidly towards vessel as U. of H. investigators are retrieving fish-attractant device (hose and floats) from floor of net. Animals circle device rapidly and then return to main body of school immediately, a distance of 150 m. observed both from the deck (Pryor) and backdown area (Vergne). (Set 13.)

Senior male squad rafting together (set 14)

Senior male squad "rafting head downwards," a behavior seen more often in juveniles.
Two occasions both set 17.

Speedboat circles near school; all animals increase swimming speed, and mother-young groups and young adult groups join with senior male squads, surrounding them, and briefly increasing one unison swimming group of three males to ten individuals, another of 8 males to 17 individuals.

Senior male squad of 3, swimming "stacked," i.e., one above the other, turn heads to investigate diver with both eyes (no echo-location).
Set 17; followed by another senior male squad, stacked, of 4 animals. (photo)

2. Mother/Baby Pairs

Observed behaviors included:

Play: Touching rostrums, monitoring, gentle pushing, play-chasing, body-rubbing and stroking.
(Appendix D presents specific case observations of mother/baby play.)

"Lost baby behavior": A small (less than half-adult size) baby, swimming in circles below adult animals (2-3 m.), whistling and making whistle trails almost continuously, and "twirling about" in one spot. In four instances, the baby joined an adult female about it after 2-3 minutes and ceased the aberrant behavior. In three instances an adult or young adult female dove down to the "lost baby," echolocated on it, nosed it with the rostrum, and then returned to the group. In two instances several adult females above a "lost baby" were observed to be inspecting it visually. In one case the "lost baby" never joined an adult and was seen engaging continually in this behavioral pattern throughout the set.

Rafting: Cases 011 and 012 constitute an adult female which alternated rafting and sinking, while her baby rubbed bodies, mouthed her pectoral fin, left her and joined another mother/baby pair, returned to her, and finally rafted, sank, and rafted with her. Many other mother/baby pairs were observed intermittantly rafting and cruising or playing (018, 021 and 022, 118 and 119, 130 and 131).

Carrying: Mother puts her blow-hole against baby's thorax, between pectoral fins, and carries baby away from investigators (3 observations, plus one on C.J. cruise).

Aggression: Aggression or agonistic behavior of any kind was rarely seen in mother/baby pairs, and never exhibited by young or less than full size. Occasionally a mother gaped at her baby especially when the mother was rafting and the baby was playful. In set 15, just before backdown, a baby spotter was dashing about in the confines of the backdown channel. Its mother pursued it and three times struck it sharp enough blows with her head to flip it about 2 m. into the air. After the third blow it took up position at her flank.

"Babysitting:" On several occasions adult females were observed with two young (babies or juveniles) exchanging stroking and body-rubbing with each. Once a small baby left its mother and returned with a larger baby, and both swam with the mother (005, 006). Once a mother was seen playing with two juveniles while another adult female followed behind. (094)

Neonates: Two neonates were seen with their mothers, in set 17, identified by the presence of fetal folds, and in one neonate, visible remnants of the umbilicus. (133, 134) As in other cases with small babies, the mothers kept to the outside of the school. Both mothers swam continuously and rapidly, at perhaps twice the speed of normal cruising animals. The babies were positioned beside and below the dorsal fin, and did not appear to be actively swimming, except for a flutter of the tail when the mother surfaced to breathe. The breathing arc was very rapid. Both mothers kept well away from other animals (10 m. or more) and moved continuously throughout the set, during repeated observations (Photograph).

Mother/Young Subgroups Observed
Behavioral Events included:

Group size fluctuation: mother/young pairs or adult females were specifically reported as joining and leaving mother/young groups in sets 3, 4, 5, 8, and 9 (spinners), 10, 12, 14 and 17. These observations included five pairs of focal animals and two individual focal animals, as well as field observations.

Rafting: mother/young pairs were often seen rafting, in the neighborhood of other rafting mothers and young.

Affiliative behavior: besides play and stroking between mother/young pairs, stroking and body-rubbing between two adult females or between a female and two young within a mother/young group were reported in sets 4, 5, 8, 12 and 13 and by set 12 were considered to be diagnostic for mother/young subgroups, when combined with assorted sizes of animals in the groups.

Aggression: no aggression or agonistic behavior, including gaping and avoidance was observed within mother/young subgroups.

Juvenile Subgroups

Observed events included:

Rafting: in set 9 a subgroup of four juveniles and two young adults rafted throughout a five-minute period (052).

Cruising: some juvenile subgroups moved calmly through the school throughout the set, reappearing unchanged though passing through masses of other animals (090, 091, 092, described in notes as "Three little maids from school." (Set 10)

Rafting head downwards: in set 10 all three observers took cases on a group of four juveniles and one adult pressed together in a circle, head downwards, throughout the set, rising only to breathe approximately every 60-90 sec. and then returning to this position (071-075; 076-077; 081-085). The same behavior was seen in a juvenile subgroup in set 12 (Photograph).

Triads

Set 14: A rapidly moving triad nearly collided with the investigators, the closest animal showing signs of panic (wide-staring, unfocussed eye). The triad halted momentarily and then did in fact collide with other animals while surfacing at high speed. The triad then slowed down on the far margin of the school, the small baby still pinned between the two adults.

Set 17: A female and neonate were briefly joined, twice, by an older female which took up the triad position (133, 134).

Courting Pairs

Behaviors observed included:

Non-aggressive pairs:

- Unison swimming
- Body rubbing
- Face-to-face melon and rostrum touches
- Beak-genital propulsion (male to female)
- Circling each other
- Stroking with flukes or pectoral fins
- 1 m. spearation with male angling towards female
- Gaping (female to male)
- Sinking together follwing (male after female)
- Intermittent rafting
- No whistle-trails

Aggressive pairs:

Female: gaping
tooth-raking
snapping
occasional whistling

Male: gaping
burst-pulse sounds
snapping
tooth-raking
circling female
pushing female with rostrum and forehead
frequent whistling
no unison swimming

APPENDIX C

Specific Occurances in Individual
Behavioral Categories

I. Aggression

Spotters:

- Set 1. Adult snapped several times at juvenile, 2 juvenile snapped back twice, the two whirled around each other several times, and juvenile swam away. (Pryor)
- Set 4. Large adult male threatened young adult male with jaws and burst-pulse sound.
- Set 8. Two males aggressively chased each other, one fled, the other followed it and drove it away, then returned.
- Set 9. Rafting male "flipped out" and lashed out all around himself with flukes swiping and jaws open.
- Set 10. Two males in a senior male squad had side-by-side aggressive exchange: one gaped, the other gaped, the first one made a threat sound and snapped, the second snapped back, nodded and gaped, the first one nodded and gaped, and then they continued swimming quietly with the rest of the squad. (087)
- Set 12. Much open-mouth threat gesturing and tooth raking reported in school (many courting pairs present).
- A male squad of four and a male squad of three, cruising in opposite directions, met face to face. The shoulder-to-shoulder animals in each squad gave open-jawed, burst-pulse threat displays in synchrony, the two squads stationary in the water and facing each other about .5 m. apart.

After an approximately 10 sec. long exchange, the squad of three dived beneath the squad of four, simultaneously, and both squads continued cruising in their previous directions. The observer was about 3 m. away from the animals.

- Set 14. Two males fenced with audible clashing of jaws on either side of and slightly ahead of a female (see "Courting Pairs").
- Set 17. Observer in the midst of crowded animals just before backdown was in the path of a large cruising male spotter and was the recipient of a threat display. Observer threatened back by waving data slate in side-to-side motion and imitating burst-pulse sound. The male ceased displaying and deflected his course slightly to pass observer at -1 m. distance.

Spinners:

- Set 5. Adult male spinner charged and rammed another adult male in the ribs. (028)
- Set 10. Two male spinners attacked each other with open, swinging jaws, threat sounds, extensive bubble production, and thrashed up and back through the surface. One gave way and fled, followed by the other. About twelve more adult male spinners instantly joined the chase, uttering burst-pulse sounds, and pursued the fleeing male for about 200 yards at a very rapid pace, across, around, and way past the rest of the school. Once away from the school the chase dissipated. Seen by all three observers.

II. Greeting:

Spotters

- Set 3. The baby of a mother/baby pair left her and returned with another baby, and both babies body-rubbed the female.

- Set 4. Juvenile swimming under main school encountered another juvenile and exchanged rostrum touches, face-to-face.

Large adult female swam alone, then joined mother/young group and body-rubbed with another large adult female, then left, joined another mother/young group, and swam and sank in unison with another large adult female (015).

A baby left its mother, joined another baby, body-rubbed and swam in unison briefly, then returned to its mother.

An adult male joined another adult male, exchanged pectoral pats, then was left by the other male.

- Set 14. A courting pair were joined by an adult female who threatened the female of the pair and then left, and then by an adult male who swam in unison with the male of the pair while the female, slightly ahead and above them, reached down with her tail and fluke-patted the first male on the back and then swam in unison with both males (108, 109).

- Set 17. A juvenile spotter female was joined by an adult female and pectoral patted, but left the female and started to raft. A large adult male approached her and she moved away. A second large adult male approached her and attempted to body-rub but she evaded him and dove deep under the school c. 30 m., and cruised alone.

Spinners

- Set 5. A large adult male approached a group of adults, emitted a "surprise bubble," and joined and swam with them (0231).
- An adult female swimming alone, was gaped at by the nearest male in a passing group. She immediately body-rubbed him and joined him, swimming in unison, for about two minutes, then hovered and cruised alone again. ().

A young adult female joined a group of 5 young adults, was gaped at by the nearest animal, left the group, joined another similar group, was gaped at again, left, joined a third group, exchanged pectoral pats with the nearest animal, and left again.

Sinking

- Set 1. Adult male spotter sideswiped another, head slapped, and then sank, rose and joined another group (002).
- Set 4. Adult male spotter joined another adult, was stroked by it, and then left by it, jostled other animals to get to the surface, and then sank briefly (014).
- Set 10. A pair of adult females in a mother-young group sank together, then rejoined the group.
 Mother/baby pair alternate sinking with rafting and episodes of play (021, 022).
 A small juvenile exhibiting Agitation Level III, accompanied by a mother in Agitation Level I, sank three times during five minutes (112).
- Set 12. A juvenile male spotter swimming with an adult female gaped at her and then sank, then cruised away, whistling (101).
- Set 14. A courting pair sank together once, then resumed cruising (108, 109).

Naturally Tagged Animals

- Set 2. Scratch on back (002).
- Set 3. Four shallow 3. cm. circular wounds with tattered edges, c.20 cm. apart, on left flank (007).
- Set 4. Tattered dorsal fin (015).

- Set 5. Adult male spotter with white spot on
 rostrum (028),
 Young male spotter with pale chevrons
 or stripes on back.
 Juvenile spotter with chevrons or
 stripes on back.
- Set 9. Large male spotter with deep, healed
 scars on both sides of caudal peduncle
 (048).
- Set 17. Juvenile female spotter with notched
 dorsal fin (120).

COMPUTER CODE DATA SHEET
FOCAL ANIMALS STUDY
BASIC DATA

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Appendix D

SET # 0 3
1 2

OBSERVER 1 (1 = Karen, 2 = Ingrid, 3 = Philippe, 9 = other)
3

CASE # 0 0 5
4 5 6

OF ANIMALS IN THIS CASE 1 (1 = single, 2 = pair, 3 = 5 or less,
7 4 = 5 or more)

SPECIES 1 (1 = spotter, 2 = spinner, 9 = other). ((describe))
8

SEX 3 (1 = unknown, 2 = male, 3 = female)
9

AGE 3 (1 = infant, 2 = juvenile, 3 = small adult, 4 = large adult)
10

OBSERVATION PERIOD 4 (1 = chase, 2 = setting net, 3 = pursing, 4 = rolling net,
11 5 = net held open, 6 = backing down, 7 = releasing,
8 = post-backdown, 9 = other) ((describe))

STARTING STATE 3 (1 = alone, 2 = paired, 3 = mother/baby pair,
12 4 = in trio, 5 = large sub-group, 6 = in main body
of school)

RELATED TO CASE # 0 0 6
13 14 15

HOW RELATED 1 (1 = mother/baby pair, 2 = other pair, 3 = same sub-group,
16 4 = fighting, 5 = courting, 6 = chasing, 9 = other)
((describe))

RELATED ALSO TO CASE #
17 18 19

HOW RELATED (same code)
20

21 24

22 25

23

COMPUTER CODE DATA SHEET
FOCAL ANIMALS STUDY
BASIC DATA

Page D-2

SET # 0 3
1 2

OBSERVER 1 (1 = Karen, 2 = Ingrid, 3 = Philippe, 9 = other)
3

CASE # 0 0 6
4 5 6

OF ANIMALS IN THIS CASE 1 (1 = single, 2 = pair, 3 = 5 or less,
7 4 = 5 or more)

SPECIES 1 (1 = spotter, 2 = spinner, 9 = other) ((describe))
8

SEX 1 (1 = unknown, 2 = male, 3 = female)
9

AGE 1 (1 = infant, 2 = juvenile, 3 = small adult, 4 = large adult)
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OBSERVATION PERIOD 4 (1 = chase, 2 = setting net, 3 = pursing, 4 = rolling ne
11 5 = net held open, 6 = backing down, 7 = releasing,
8 = post-backdown, 9 = other) ((describe))

STARTING STATE 3 (1 = alone, 2 = paired, 3 = mother/baby pair,
12 4 = in trio, 5 = large sub-group, 6 = in main body
of school)

RELATED TO CASE # 0 0 5
13 14 15

HOW RELATED 1 (1 = mother/baby pair, 2 = other pair, 3 = same sub-group,
16 4 = fighting, 5 = courting, 6 = chasing, 9 = other)
((describe))

RELATED ALSO TO CASE #
17 18 19

HOW RELATED (same code)
20

21 24

22 25

23

COMPUTER CODE DATA SHEET
FOCAL ANIMAL STUDY

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CASE # 006

GENERAL COMMENTS:

Baby of 005.

COMPUTER CODE DATA SHEET
SEQUENTIAL BEHAVIOR CODING

Page 1-4

CASE # 005

CT2	BR1	RB1		
RB1	DV	RB1		
RB2	BR1	RB2		
SU	DV	RB2		
BR1	PE1			
DV	JN17			
RB1	RB1 BJ4			
RB2	BB1			
CT1	CT1			
BB1	RB1			
AV2	CH3			
SU	BR1			
BR1	CT1			
JN15	BB1			
LV1	LV2			
PE1	RB1 BJ2			

COMPUTER CODE DATA SHEET
SEQUENTIAL BEHAVIOR CODING

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CASE # 006

CT 2	DV			
RB 1	BR 1			
RB 2	DV			
SU	PE 2			
BR 1	JN 4			
DV	BJ 4 PE 1			
RB 1	CT 1			
RB 2	RB 2			
UB BR 1	CH 2			
AV 2	BR 1			
SU	CT 1			
BR 1	BB 1			
JN 5	LV 1			
LV 1	JN 2			
PE 2	JN 1			
BR 1	RB 1			

CASE # 005

GENERAL COMMENTS:

Mother + large baby playing by themselves at first, below main body of milling subgroups & rafting subgroups, school of 60+. Mother mouthed baby's dorsal finstock. They rubbed bodies, surfaced, breathed together, dived, rubbed bodies. Mother pushed baby with beak to genitals, gently, whistling bubble trail. They ~~avoided~~ swam away from me in avoidance & surfaced & joined a big group, then parted from it. Mother patted baby w pec. fin. BR, DV, BR, DV, pat baby again. Joined ~~two~~ other females: you & 2 females & 2 babies were joined by 4 adults. Mother whisked BR1, kissed baby i.e. touched rostrums face to face. She rubbed bodies & chased baby a little. BR1. More lussing, more whistling. ~~Left~~ Baby left her & came back with another slightly larger baby & both swam with mother. If ever I saw a peaceful, cheerful scene, it was this one. Aside from some avoidance of me, and the group as a whole was avoiding us at first a lot, gradually diminishing to much less almost none.

APPENDIX E

COMPARATIVE FREQUENCY OF BEHAVIOR EVENTS ACROSS SUBGROUPS

Note: Columns "a" list average number of times this behavior was performed by each animal in the group. Columns "b" list percentage of animals in group exhibiting this behavior (to nearest %). Parenthesized number in column "a" are maximum number to times any animal performed the behavior in a 5 minute period.

Behavior	n = 18		n = 10		n = 11		n = 16		n = 6		n = 11	
	mothers with young	a	juvenile subgroups	b	young adult subgroups	a	dominant male subgroups	a	alone	b	courting pairs	a
Affiliative												
play-chase	.38(2)	12%										
touch heads or rostra	.13(2)	24%	.10(1)	10%							.09(1)	9%
gentle mounting (given or received)	.22(1)	11%										
fluke pat	.22(1)	12%										
pectoral pat	.22(2)	9%			.09(1)	9%	.06(1)	6%			.09(1)	.09%
push another animal through water	.33(1)	17%									.18(1)	18%
rub bodies	.58(5)	33%	.30(1)	30%	.09(1)	9%					.27%(2)	18%
											.54(1)	36%
Aggressive												
gape	.16(1)	6%	.10(1)	10%	.09(1)	9%	.25(4)	6%	.16(1)	17%	.90(4)	36%
be gaped at							.18(2)	12%			.45(3)	27%
jaw snap or strike	.05(1)	3%			.09(1)	9%	.06(1)	6%			.63(4)	36%
tooth rake											1.7 (7)	27%
strike with pectoral	.05(1)	3%	.10(1)	10%								
strike with flakes									.16(1)	17%	.09(1)	9%
threat sound (burst pulse)							.12(2)	6%	.16(1)	17%	.63(2)	36%
rake gesture											.27(2)	18%

